Essays on alternative investments

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ter verkrijging van de graad van doctor aan Tilburg University op gezag van prof. dr. G.M. Duijsters, als tijdelijk waarnemer van de functie rector magnificus en uit dien hoofde vervangend voorzitter van het college voor promoties, in het openbaar te verdedigen ten overstaan van een door het college voor promoties aangewezen commissie in de Portrettenzaal van de Universiteit op maandag 24 juni 2019 om 10.00 uur

door

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Marshall 馬曉崟

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Table of Contents

Introduction

Art is an important alternative asset class. High-net-worth individuals (HNWIs) hold on average 9% of their investment portfolios in art and other types of collectibles (such as Bordeaux wines, classic cars, superior watches, etc.). The total value of collectibles held by HNWIs is estimated at more than USD 4 trillion (Deloitte, 2013). Purchases of art through auction houses and internet-auctions have been growing rapidly over the past two decades (Deloitte, 2016) and global art sales are estimated to have exceeded USD 63 billion in 2018 (Art Basel, 2018). Past studies have focused on risk-return relationship of art, financial and macro-economic market drivers, sentiment and hypes, behavioral anomalies, gender biases, and correction for selection biases.

As art yields not only a financial return but also emotional dividends, this doctoral thesis tries to link financial performance, pricing factors, and emotional aspects in a complete piece. Chapter 1 investigates the overall financial performance of art markets, Chapter 2 and 3 study novel pricing factors (colors and provenance), and Chapter 2 finds the emotional channel between abstract art and purchasing valuation.

In chapter 1, I give a financial overview of modern art market in the past sixty year and study the price determinants and investment performance of art. This chapter is coauthored with Yuexin Li and Luc Renneboog. This chapter applies a hedonic regression to over two million auction transactions of paintings. This research concludes that art has appreciated in value by a moderate annualized return of 2.49%, in real U.S. dollar terms, between 1957 and 2016. A three-stage repeat sales and an adjacent-period repeat sales analyses confirm that the results are robust. Next, I investigate the investment performance of paintings by price levels, media, movements, markets, auction houses size, artist nationalities, market segmentations, and artists' life and career cycle. In particular, *Minimalism & Contemporary*, *Pop*, and *Abstract Expressionism* artworks perform well in the sixty-year period with annualized real returns of 17.70%, 9.00%, and 6.22%, respectively and their performances are resilient in the recent financial crisis. Finally, I compare the investment performance and correlation of painting investment with other art and financial assets.

Paintings exhibit negative correlations with stock and bond markets and receives about 7.6% weight in optimal portfolio.

In chapter 2, I study the impact of colors of paintings on prices in the art auction market and incorporate color attributes of non-figurative paintings in pricing models. This chapter is coauthored with Charles N. Noussair and Luc Renneboog. As stated by Philip Hook, a board member and the director of Impressionist & Modern Art by Sotheby's London, there are many factors driving the art sales results including composition, colors, and emotional powers conveyed. Mr. Hook specifically mentioned that blue and red are good news (*The Guardian*, 18 Nov. 2013). In order to test the pure color effects, this study focuses on non-figurative abstract art and therefore isolates the color effects from composition. In order to establish the causality from colors to emotions to valuation, this study combines real auction analysis with a large-scale laboratory experiment. In the real auction analysis, I analyze the color attributes on pixel level on painting images from real auction and incorporate them into pricing model. I find that a one standard deviation increase in the percentages of blue (red) hue leads to premiums of 10.63% (4.20%). The hue percentage increases the adjusted R^2 by about 15 percentages and other color attributes (mainly saturation and luminosity) doesn't add much explaining power to and are not significant in the hedonic model. In the experiment part, I have personally conducted experiments with more than 480 subjects in Shanghai, P.R. China, Tilburg, the Netherlands, and Tucson, U.S.A. I used the BDM method to elicit participants' willingness-to-pay on abstract paintings of single and dual colors and asked participants to self-report emotional states (pleasure-arousal) after viewing each painting. I find that blue (red) paintings command 18.57% (17.28%) higher bids and stronger intention to purchase. Although abstract art is visually arousing, it is the emotional pleasure channel that relates colors and prices. The results are consistent across all three cultures.

In chapter 3, I study the associations between provenance information and paintings' sale probability, price, and return. This chapter is coauthored with Yuexin Li and Luc Renneboog. I collect provenance data and apply textual analysis to categorize it into information relating to pedigree (ownership chains relating buyers to artists), exhibition history (museums, art fairs, cultural cities), literature coverage, and authentication

(physical and non-physical proof of authenticity by artists, experts). I find that provenance information on average is associated with increases the artwork's probability of being sold by 3% and price premium by 30% after controlling for artwork characteristics (such as topic, authenticity), artist, time, and auction house fixed effects. In addition, the incremental provenance for the pair of the repeat sales has a positive impact on artwork return. I find that provenance is an important indication of art authenticity as well as a vital pricing factor. It especially matters for smaller auction houses and galleries.

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Chapter 1. Sixty Years of Modern Art Markets: On Painting Prices and Returns

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ABSTRACT

This paper studies the price determinants and investment performance of art. We apply a hedonic regression to over two million auction transactions of paintings. We conclude that art has appreciated in value by a moderate annualized return of 2.49%, in real U.S. dollar terms, between 1957 and 2016. A three-stage repeat sales and an adjacent-period repeat sales analyses confirm that our results are robust. Next, we investigate the investment performance of paintings by price levels, media, movements, markets, auction houses size, artist nationalities, market segmentations, and artists' life and career cycle. In particular, *Minimalism & Contemporary*, *Pop*, and *Abstract Expressionism* artworks perform well in the sixty-year period with annualized real returns of 17.70%, 9.00%, and 6.22%, respectively and their performances are resilient in the recent financial crisis. Finally, we compare the investment performance and correlation of painting investment with other art and financial assets. Paintings exhibit negative correlations with stock and bond markets and receives about 7.6% weight in optimal portfolio.

Keywords: Auction; art investment; cultural economics.

JEL Code: D44, G20, G11, Z11

1. Introduction

Art news has rarely failed to catch the attentions from audience of various backgrounds and tastes. One recent striking auction was that *Salvator Mundi* was sold by Christie's for $450.3 million in November 2017 after 20-minute fierce bidding. And this auction refreshed the world auction record after 14 months when *Interchange* made by Willem de Kooning was sold for about $300 million. There is still one fact that surprises the market besides the baffling amount of money paid: this artwork had only been authenticated to be a *bona fide* Leonardo da Vinci in the beginning of 21st century and it was sold for £45 in 1958 via Sotheby's London. Questions naturally kick in: what are the price determinants? And what are the return risk features of the modern art auction market in the past sixty years?

The modern art market has been growing very quickly from a Europe dominated market in 1950s to a global market with participations from more than 30,000 auction houses and with artworks created by more than 150,000 artists. The global art sales are estimated to have exceeded USD 63 billion in 2018 and the dominant art form is paintings (Art Basel, 2018). In this paper we collect close to three million painting auction transactions in the 1957-2016 period and apply a comprehensive hedonic regression to calculate index return series. Our hedonic variables include artist, artwork, provenance, and transaction features. As a robustness check, we also apply a three-stage weighted least-square repeat sales regression and an adjacent-period repeat sales regression. Our results show that artist reputation, attribution, signs of authenticity, medium, size, topic, provenance information, and the timing and location of the sale are significantly correlated with price levels. Based on the regression coefficients before the year dummies in our model, we can build a price index that controls for time variation in the composition of the market. We find that constant-quality art prices increased by a moderate 2.49% in real USD terms on a yearly basis over the 1957-2016 period. Our results are substantially below those reported by Goetzmann (1993), Mei and Moses (2002), Renneboog and Spaenjers (2013), Spaenjers, Goetzmann, and Mamonova (2015), and Korteweg, Kräussl, and Verwijmeren (2016) but higher than Pesando (1993). It's noteworthy that Goetzmann (1993), Pesando (1993), Mei and Moses (2002), and Spaenjers, Goetzmann, and Mamonova (2015) are limited to selective (higher-end) artworks and are much less in terms of market coverage. To better understand the characteristics of modern art auction markets, we investigate our

investment performance in different holding periods including bubble and bust periods, in subsamples by price levels, art media, art movements, art markets, auction houses size, artists nationalities, market segmentations, and artists' life and career cycles. We find that the return and risk are much higher in the first three decades compared to the recent three decades, and oil paintings, more recent art movements (e.g. *Minimalism & Contemporary*, *Pop*, and *Abstract Expressionism*), British auctioneers or the big four auction houses (Sotheby's, Christie's, Bonhams, and Phillips) or an international auction market, Russian or Spanish arts, artworks made in the last one-third career cycle of deceased artists are good news for an art investor solely focusing on monetary aspects. We also study investment performances and correlations between paintings and other minor Art investment vehicles. An investment on the generalized average painting is not outperforming other minor and specific collectible goods such as British stamps, red Bordeaux wines, classic cars, and white diamonds but the return is higher than the generalized average sculpture investments. The correlation between painting investment is strongly positive with sculptures and white diamonds, moderate with classic cars, and very small or negative with red Bordeaux wines and stamps.[1] The correlation between paintings and stock (bond) markets are moderately negative while painting real returns are significantly positively correlated with gold and US housing market.

The relevant academic literature in finance has focused on the risk-return relationship of art (Mei and Moses (2002), Renneboog and Spaenjers (2013), Korteweg, Kräussl, and Verwijmeren (2016), and Lovo and Spaenjers (2018)), its financial and macro-economic market drivers such as equity market evolution and income inequality (Goetzmann, Renneboog, and Spaenjers (2011), sentiment and hypes (Pénasse, Renneboog, and Spaenjers (2014)), gender biases (Adams, Kräussl, Navone, and Verwijmeren (2017), Bocart, Gertsberg, and Pownall (2017), and Cameron, Goetzmann, and Nozari (2019)), and whether behavioral anomalies such as anchoring (Beggs and Graddy (2009), and Graddy *et al.* (2015)) appear in the art market.

Although art investment is a combination of financial investment and emotional investment (namely the investor benefits not only from the monetary returns but also from mental dividends), this paper focus on the financial performance of art. In line

[1] Returns are obtained and calculated from Dimson and Spaenjers (2011), Renneboog and Spaenjers (2012), Dimson, Rousseau, and Spaenjers (2015), Vosilov (2015), Laurs and Renneboog (2019).

with Ashenfelter and Graddy (2003), we have to admit that the estimated returns on art vary with data, methodology, and the time period under consideration. Regarding return calculations, different methodologies have been used in prior researches. Earlier works use simple methods without considering controlling for quality (Stein (1977), Baumol (1986), and Frey and Pommerehne (1989)).[2] More recent studies have therefore used either hedonic regressions or repeat sales regressions to estimate the price movements of art and other illiquid assets (like real estate etc.).

The benefit of using hedonic regressions is controlling for quality changes in the transacted goods by attributing implicit prices to their "utility-bearing characteristics" (Rosen (1974)). In the often-used time-dummy variant of the hedonic pricing methodology, all available transaction data are pooled, and prices are regressed on a set of value-determining attributes including time-dummies. Under the assumption that all omitted characteristics are orthogonal to those included (Meese and Wallace (1997)), the coefficients on the time dummies account for constant-quality price trends over the sample period. Since no information is thrown away prior to the estimation, hedonic regressions make efficient use of available data, and may therefore give more reliable estimates of price indices than repeat sales regression.

Repeat sales regressions explicitly control for variations in quality between works by only considering items that have been entered the market for resales. The method uses purchase and sale price pairs to estimate the average return of a portfolio of assets in each time period. One major issue is that only about 2% of artworks will reenter the market constituting a pair of repeat sales. Only considering repeated transactions decimates any data set to a relatively small number of observations and misrepresent the market.[3] Meese and Wallace (1997) show that the use of such small databases renders repeat sales regression estimators sensitive to influential observations. Second, most repeat-sales studies suffer from selection issues. For example, the sample used by Mei and Moses (2002) includes paintings with a first transaction anywhere in the world, but a resale at Sotheby's or Christie's New York, arguably the most expensive sales rooms in the world. Moreover, the initial purchase is identified using the entries in the

[2] Stein (1977) considers the auctioned objects each year as a random sample of the underlying stock of art (by deceased artists) and constructs an index based on the yearly average transaction price. Baumol (1986) and Frey and Pommerehne (1989) calculate the geometric mean return on works that sold at least twice during the considered time frame.

[3] For example, Mei and Moses (2002) include 4,896 sales pairs over a period of 125 years; Goetzmann, Renneboog, and Spaenjers (2011) use even fewer sales pairs, although their focus is not on the resulting price index itself.

New York sales catalogues; information on provenance could be more likely to be included when a high price is expected. An index estimated based upon such a sample may thus be biased upwards.[4] Korteweg, Kräussl, and Verwijmeren (2016) provide with a theoretical framework to correct for sample selection. The application cuts art returns are cut about 28% of index return (from 8.7% to 6.3%), halves Sharpe ratio, and changes optimal portfolio weights. Lovo and Spaenjers (2018) present an infinite-horizon model of endogenous trading in art auction market.

This paper proceeds as following: Section 2 describes methodology and data, Section 3 reports art price indices composed from baseline model and by different categories, Section 4 reports return and risk features of art market, and Section 5 concludes.

2. Methodology and Data

2.1 Methodology

2.1.1 Hedonic Model

To investigate the effects of various hedonic variables (independent variables) on price, we start with hedonic price regression. We take the natural logarithm of real USD hammer prices.[5] The main advantage of hedonic model is that information on all observed transactions is included. Our model include a wide range of hedonic characteristics and the specification is:

$$\ln(Price_{kt}) = \alpha + \sum_{m=1}^{M} \beta_m \, Artist_{mkt} + \sum_{p=1}^{P} \beta_p \, Artwork_{pkt} + \sum_{q=1}^{Q} \beta_q \, Provenance_{qkt} + \sum_{n=1}^{N} \beta_n \, Transaction_{nkt} + \varepsilon_{kt} \quad (1),$$

where $Price_{kt}$ represents the hammer price of art object k at time t, $Artist_{mkt}$ is an artist-specific attribute m of item k at time t, $Artwork_{pkt}$ is a set of artwork specific

[4] Additionally, many repeat sales studies work with *Reitlinger Data* – books with auction price data until the 1950s. It is well known that they are incomplete and focus disproportionately on famous artists (Guerzoni, 1995).

[5] The Blouin database gives either the hammer prices or the premium price, which is the hammer price plus a commission averaging 15%, paid by the buyer. Given that the actual percentage of the commission is not available, we divide the premium price by 1.15 as an approximation of the hammer price. The hammer price is then deflated by US CPI taking 1957 as the basis year.

attribution, physical, and topic attribute *p*, $Provenance_{qkt}$ is a provenance-related attribute *q*, $Transaction_{nkt}$ is transaction-level attribute *n*. The coefficients β reflects the relative shadow prices of the corresponding characteristics. Thus, this model accounts for a set of attributes related to artist, transaction, physical art object, provenance information. We will describe all the hedonic and provenance variables in data subsection. Specifically, if we denote the coefficient before year *t* as β_t then the hedonic index for year *t* is:

$$\Pi_t \equiv \exp(\widehat{\beta_t}) \times 100 \quad (2),$$

with the time dummy coefficient set to 0 for the first, left-out period. This gives an estimated return in year *t* of:

$$r_t \equiv \frac{\Pi_t}{\Pi_{t-1}} - 1 \quad (3).$$

One subtle yet important issue is that such an index generated by equation (2) tracks the geometric instead of the arithmetic mean of prices over time. This is caused by the log-transformation on dependent variable. If there is time-varying dispersion of prices, a correction method is required to implement (Renneboog and Spaenjers (2013), Silver and Heravi (2007), Triplett (2004)). We assume that the hedonic regression residuals are normally distributed in each period, then we define the corrected index and return as following:

$$\Pi_t^* \equiv \exp\left(\widehat{\beta_t} + \frac{1}{2}(\hat{\sigma_t}^2 - \hat{\sigma_0}^2)\right) \times 100 \quad (4),$$

where $\hat{\sigma}_t$ and $\hat{\sigma}_0$ are the estimated variances of the residuals of observations in periods t and 0, respectively. The corrected return estimate in year *t* is defined as follows

$$r_t^* \equiv \frac{\Pi_t^*}{\Pi_{t-1}^*} - 1 \quad (5).$$

2.1.2 Return Unsmoothing

Based on the coefficients of year fixed effects derived in equation (1), we can derive the index series of the art market. Underestimating the true standard deviation is a problem for the appraisal-based index returns, which results from a tendency among

appraisers to lag true value changes (Geltner (1991)). Art as an investment is less liquid comparing with traditional financial assets due to the lack of a continuous auction market. The appraisals of the illiquid art asset depend on the past prices and take more time to adjust the prices. Therefore, the first differences in index levels can be autocorrelated. To adjust the appraisal smoothing of return series, we apply the unsmoothing methodology, a technique originated in real estate literature and later used in alternative investment returns (Geltner (1993), Dimson and Spaenjers (2011)).

If we assume that all items are reappraised at the end of each period, the observed (smoothed) return in period t, R_t, can be expressed as a weighted average of the true (unsmoothed) return in period t, R_t^u, and the smoothed return in the previous period, R_{t-1} (Geltner (1993)):

$$R_t = (1-\alpha)R_t^u + \alpha R_{t-1} \quad (6),$$

The appraisal smoothing factor α is a fraction between 0 and 1 and can be determined by the autocorrelation coefficients. Eq. 6 can be inverted to obtain the unsmoothed return series R_t^u from the observed returns R_t and R_{t-1}:

$$R_t^u = \frac{R_t - \alpha R_{t-1}}{1-\alpha} \quad (7),$$

We can then obtain the adjusted standard deviation by the unsmoothed return R_t^u.

2.1.3 Repeat Sales Model

Another method to obtain return series other than deriving returns from the hedonic index is to calculate pairwise return of repeat sales. To obtain the repeat sales returns, we first identify pairs of repeat sales within our sample. We select repeat sales candidates for each artist based on the exact title and size. We then manually rule out false pairs. We calculate the returns based on hammer prices in USD from two adjacent auctions of the same painting.

We assume that that the continuously compounded return for a certain painting i in period t, $r_{i,t}$, equals the continuously compounded return of a price index of art (μ_t) plus an error term $\eta_{i,t}$:

$$r_{i,t} = \mu_t + \eta_{i,t} \quad (8),$$

where μ_t can be regarded as the average return of paintings in the portfolio in period t. We use repeat sales data about individual paintings to estimate the price index μ_t over time interval $t = 1, .2, .., T$. The return of individual painting i, r_i, can be expressed as the log of sale price ($P_{i,s}$) divided by purchase price ($P_{i,b}$). According to equation (8), r_i can be rewritten as the sum of return $r_{i,t}$ during the whole holding period from $b_i + 1$ to s_i. b_i and s_i represent the dates of purchase and sale, respectively.

$$r_i = ln(\frac{P_{i,s}}{P_{i,b}}) = \sum_{t=b_i+1}^{s_i} r_{i,t} = \sum_{t=b_i+1}^{s_i} \mu_t + \sum_{t=b_i+1}^{s_i} \eta_{i,t} \quad (9),$$

We follow Case and Shiller (1987) and apply three-stage estimation procedure. In the first stage, we apply ordinary least squares (OLS) and regress returns, $ln(\frac{P_{i,s}}{P_{i,b}})$, on a matrix (containing a row for each painting and a column for each holding time period) with dummy variables indicating the holding period of each painting. In the second stage, we regress the squared residuals from the first stage on the time span between sales and an intercept. In the third stage, we repeat first stage regression while using weighted least-squares, with the fitted squared residuals in the second stage as weights. The coefficients we obtain in the third stage are the corresponding returns for each period.

2.1.4 Adjacent-period Repeat Sales Model

One major assumption in the pooled repeat sales regression is that the price impact of all hedonic variables is set to be stable in the entire sample period. Instead of the pooled method used in the Repeat Sales, we can also apply the adjacent-period hedonic method to account for time-varying hedonic shadow price. The adjacent-period repeat sales method account for the possibility of fluctuating shadow prices of hedonic variables. We apply this method to our data set by performing a separate hedonic regression for every two consecutive years since 1957, and the chain-linking our

returns.[6] Regardless of the specification of whole sample period or adjacent-period repeat sales return analysis, he main advantage is controls for the uniqueness of each work. Also, in contrast to a hedonic price index, it can be thought of as an investable index, at least in theory.

2.1.5 Quantile Regression

Art market is segmented for a number of reasons. First, art is indivisible, and therefore small investors are generally not able to invest in higher-end works. Second, wealthy individuals may be less likely to buy in the lower-end of the market, where works do not signal the same social status (Mandel (2009)). Third, the more expensive parts of the market may be more prone to speculation. The distribution of returns could thus be skewed over and above a potential masterpiece effect. In such a setting, quantile regressions can be particularly useful (Zietz *et al.* (2008), Scorcu and Zanola (2011)). While OLS regressions provide estimates for the conditional means only, non-linear quantile regressions can characterize the entire distribution of the dependent variable (Koenker and Hallock (2001)). In our setting, this implies that the pricing of hedonic characteristics and the changes in price levels over time are allowed to vary across the distribution of auction prices itself.

We run a quantile variant of our adjacent-period hedonic regression model for every two-year period since 1957 for the following percentiles: 0.95, 0.75, 0.50, 0.25, and 0.05. We split our sample in subperiods to make sure that the quantile regression coefficients pick up variation in the valuation of hedonic attributes across price brackets rather than across time. The quantile hedonic price indices Q95, Q75, etc. are then constructed by chain-linking the coefficients on the year dummies for the relevant quantiles.

2.2 Data

2.2.1 Data and Variables

We start our analysis with a unique data set spanning six decades from 1957 to 2016 covering auction houses and art galleries all over the world. We have obtained 2,874,652 auction records of paintings (including oil paintings, watercolors, and

[6] We set the first year in each separate regression as omitted benchmark and calculate the index for the second year. We then immediately take the index number for the second year in the previous separate regression as a multiplier to adjust for the level.

drawings) made by 155,156 artists from Blouin. Among these auction records, 2,257,485 lots (78.53%) made by 100,593 artists were successfully sold with price information [7] and with artist-, transaction-, artwork-, and provenance-related information, if available. We also collect artist biography information from Grove Art Online maintained by Oxford University Press in order to cross-check artist nationality, and birthday (birth year or birth century) and to match art movement classification. We categorize these information as following:

First, the set of $\boldsymbol{Artist_{mkt}}$ variables comprises:

1. *Artist dummies.* We include artist fixed effects to account for artists' reputation and other personal traits.

2. *Deceased artist dummy.* This dummy equals one for sales after the artist's death, as it is often assumed that prices for art works increase after the artist's death.

3. *Nationality dummies.* We collect artist nationalities information and create 9 nationality dummies for artist. These are American, Belgian, British, Dutch, French, German, Italian, Spanish, and Russian. We follow the common practice and perception in the art world and allow for multiple nationalities.

4. *Art movement dummies.* Based on the art movement information from Grove art online, we manually matched the artists and classified them into the following 13 art movements: Medieval & Renaissance; Baroque; Rococo; Neoclassicism; Romanticism; Realism; Impressionism & Symbolism; Fauvism & Expressionism; Cubism, Futurism & Constructivism; Dada & Surrealism; Abstract Expressionism; Pop; Minimalism & Contemporary. The left-out benchmark is unclassified artists.

Second, we include a vector of price-determining variables ($\boldsymbol{Artwork_{pkt}}$) capturing the physical, attribution, authenticity, and topic characteristics of the painting. We use variables that capture the medium, size, and authenticity of the work of art:

1. *Attribution dummies*. As attribution uncertainty can be an important factor discounting the price of art objects (especially of older works), we generate a dummy variable that captures doubts about the identity of the creator of the painting.[8]

[7] The Blouin database gives either the hammer prices or the premium price, which is the hammer price plus a commission averaging 15%, paid by the buyer. Given that the actual percentage of the commission is not available, we divide the premium price by 1.15 as an approximation of the hammer price.

[8] Different levels of attribution are used in the art auction world: attributed to, studio of, circle of, school of, after, and in the style or manner of.

2. *Authenticity dummies*. The dummy equals one if the auctioned lot contains any of the physically identifiable markings - signature, date, or inscription - that confirm the authenticity of the art piece.

3. *Medium dummies*. We introduce dummies for Oil paintings, Watercolors (including gouaches), and Drawings.

4. *Size*. The height and width in centimeters are represented by Height and Width and their quadratic forms Height_Sqr and Width_Sqr.

5. *Topic dummies.* We categorize the works in different topic groups based on the keywords of the artworks' titles and account for 7 major languages used in art auction world.[9] We have 13 categories: Abstract, Animals, Landscape, Seascape, Urbanscape, Nude, People, Self Portrait, Portrait, Religion, Still Life, Study, and Other Topics. Untitled is used as the omitted benchmark in our regressions.

Third, we include a set of variables $\boldsymbol{Provenance_{qkt}}$ containing provenance information offered in the auction catalogue.

1. *Provenance dummy*. This dummy equals one if there is textual information in the catalogue about the provenance (past ownership, previous sales information, etc.) of the auctioned lot.

2. *Literature dummy*. This dummy equals one if there is textual information in the catalogue about the literature coverage of the auctioned lot. Art-related literature include scholarly articles, art critics, art catalogues, *catalogue raisonné,* etc.

3. *Exhibition dummy*. This dummy equals one if there is textual information in the catalogue about the exhibition history of the auctioned lot.

4. *Authentication dummy.* This dummy equals one if there is textual information in the catalogue about the associated authentication either in the form of physical certificate or oral confirmation.

Fourth, we include the dummy variables $\boldsymbol{Transaction_{nkt}}$ that stand for transaction level attributes such as the timing of the sale, and the reputation and location of the auction house:

[9] They are English, Dutch, French, German, Italian, Spanish, and Portuguese. In our other string search exercises, we also compile keywords in these 7 major languages if necessary and have the keywords list checked by native speakers.

1. *Auction house dummies*. We introduce auction house fixed effects for every auction house at the branch level. We distinguish among the different fine art auction houses based on reputation. For Sotheby's and Christie's, we introduce dummy variables for their London, New York, and other sales rooms (e.g., Sotheby's London, Sotheby's New York, and Sotheby's Other Branches). Together, these two institutions account for more than 32% of all sales in our sample. For two other big British auction houses, Bonhams and Phillips, we make a similar distinction among their London, New York, and other sales rooms (See Appendix). We also report the effect of selected smaller but important American and European auction houses in our analysis.

2. *Month dummies*. Important sales are often clustered in time, and the busiest months are May/June and November/December. January is omitted and serves as benchmark.

3. *Year dummies*. We include year fixed effects and the exponential of the coefficient of each year's fixed effect yields an index number for the corresponding year. Therefore, we can calculate index returns based on the index series.

2.2.2 Summary Statistics

In the 2.3 million successful sales, 82% of them took place after the death of artists. The average (median) hammer price is about USD 47,000 (USD 4,000). From 10% to 19% of artists in our sample are born or working in France, USA, Belgium and the Netherlands, UK, and Italy making these countries or regions the top motherlands for artists. Artworks related to Baroque, Impressionism & Symbolism, and Fauvism & Expressionism constitute the best-selling art movements. An average painting in our sample is 56 cm in height and 58cm in width. 65% of the sales are oil painting, 19% are watercolors (or gouaches), and 16% are drawings. For physical traces to confirm authenticity, 71% of paintings are signed in at least on of the various forms: full name(s), monogram(s), initials, countersignature(s), and stamp(s). 35% of paintings are dated while 13% are inscribed. About 3% of paintings sold are not certain to be authentic carrying a discounting factor of being attributed to an artist. 43% of paintings don't have a clear topic as determined from the tile text. The most common non-abstract topics are paintings of landscape (16%) and people (11%). In the category of provenance information, about 14% of paintings contain pedigree information, about 5% of paintings had been exhibited before, about 5% of paintings are covered in art-related

literature, and 2% of paintings are sold with proofs of authentication (either in a physical form or an oral confirmation). Art sales per year since 21st century are multiple-fold of sales number in 20th century and this is in line with art market development. We observe that May/June season and November/December season account for more than 25% of sales, respectively. This is because important auctions are usually clustered around the Spring/Autumn sale. Sotheby's and Christie's as the two most prominent auction houses handles 32% of the sales in the past 6 decades and their London and New York sales room are the most important branches to provide liquidity.

Although we have provided an approximation to account for buyer's premium, we have to acknowledge that it is very hard to correct for the transaction cost from the seller's side due to the fee structure complexity and information unavailability. Unlike a uniform or progressive commission fee structure from the buyer's side, the seller's commission largely depends on seller's status (private client, dealer, or museum), number of lots in one auction (few items vs. a large collection), and transaction amount in the auction year or over past years. This information is rarely disclosed by auction houses. Wall Street Journal (2010) reports the insurance cost as about 1% per annum of the art value. Our analyses are therefore on a hammer-on-hammer basis.

[Insert Table 1 about here]

3. Art Price Indices

3.1 Baseline Indices

3.1.1 Baseline Hedonic Regression

Table 2 shows the estimates of the hedonic variables for our hedonic price regression. Eq. (1) is estimated using ordinary least squares (OLS) and the dependent variable is the natural log of hammer price in USD deflated to 1957. Column (1) presents the coefficients and Column (2) shows the corresponding price impacts, which can be approximated by taking the exponent of the coefficient and then subtracting one. For 2,163,281 sales we have complete information on all hedonic characteristics presented in the previous section.

We have consistent results in the baseline regression with Renneboog and Spaenjers (2013). Artworks with attribution "style", "after", "school", "circle", "studio", and

"attributed" are priced with large discounts ranging from 50 to 80 percent. Signed, or dated artworks tend to have close to 20% premium compared to artwork without any physical traces of authenticity. Oil paintings and watercolors are priced 235% and 57% higher than the drawings, respectively. Furthermore, prices increase with size, up to the point that the work becomes too large, which is indicated by the negative coefficients on the squared terms. In addition, artworks on Portraits, Studies, and Nudes are traded with discounts while topics like Self-portrait, Urbanscape, Seascape, and Still-life command an 8% to 20% premium. Paintings with Pedigree, Exhibition, Literature, or Authentication information are likely to have more exposure and to be more reliable in authenticity. These Pedigree, Exhibition, and Literature information contribute to an extra 36% to 56% premium while paintings with Authentication are sold 11% more expensive compared with the paintings without any provenance information.[10] Sotheby's London and Christie's London sell artworks with highest prices on average almost doubling the price when compared to an average auction house in sample. The most expensive auctions are clustered in May, June, November and December.

[Insert Table 2 about here]

3.1.2 Indices and Returns

Based on the coefficients on the time dummies and the estimated variance of residuals in each period, we construct the uncorrected and corrected price indices following the equations in Methodology and Data section. The corrected index is used to correct for the geometric mean of prices over time due to the log transformation prior to estimation. We set the price levels as 100 in year 1957 and the results are reported in Table 3.

[Insert Table 3 about here]

In addition, we include the repeat sale index over 1957 to 2016 in Table 3. The repeat sale method can control for the uniqueness of each painting and is usually regarded as a more investable index in theory. We match the repeat sales using artist

[10] For detailed discussion about the association between provenance and painting prices and returns, see thesis chapter *Provenance in the Art Market.*

name (excluding all the artworks with attribution “style”, “after”, “school”, “circle”, “studio”, and “attributed”), size, title (excluding “untitled”, “study” and other general titles), medium, and the presence of signature and date. We exclude all the repeated transactions with a holding period of less than half a year and identify 63,430 repeat sale pairs in our sample. In line with Goetzmann (1993) and Mei and Moses (2002), we apply a three-stage estimation procedure (Case and Shiller (1987)) on our sample of repeat sales.

Figure 1 depicts the evolution of the corrected and uncorrected indices over 1957 to 2016. Figure 1 shows the marked deviations between corrected and uncorrected indices over the sample period, which indicates the quantitative importance of the correction for the log transformation.

[Insert Figure 1 about here]

There are two boom periods in our sample periods: 1982-1990 and 2002-2007. The price index reached around 800 for uncorrected index and around 700 for corrected index. The annual increase in real prices exceeded 20% from 1986 to 1990. Hiraki *et al.* (2009) show that the Japanese equity bubble largely influenced the international art prices in the first bubble period, especially the prices of Impressionism paintings preferred by the Japanese collectors. The second bubble period in 2002-2007 was mainly caused by the large equity market increase before the financial crisis in 2007. However, the magnitude of the second boom in 2002-2007 is smaller comparing with the first boom period of 1982-1990. The repeat sale index has similar price trend with the corrected index before mid-1990s and has higher price trend after mid-1990s.

A potential problem of the hedonic model is that the coefficients are constrained to be stable across the whole sample period. However, the shadow prices of hedonic characteristics may change over time. Accounting for the taste change, we apply adjacent-period model to mitigate this problem by dividing the sample in subperiods (Renneboog and Spaenjers (2013)). We run regressions for every two consecutive years and then link the coefficients on time dummies. Table 4 presents the price index and returns for the adjacent-period hedonic regressions and Figure 2 depicts the price index. The adjacent-year model generates similar price trends we obtained from the pooled data, which supports our baseline results.

[Insert Table 4 and Figure 2 about here]

In summary, we find that repeat sale sample experience a two-fold real return in the past six decades while corrected index real return is about 100%. Adjacent-period hedonic index gives an accumulative real return of 37% in the past 60 years.

The annualized real return and volatility based on uncorrected hedonic index are 2.90% and 15.91%, respectively; based on corrected hedonic index are 2.49% and 16.21%, respectively; based on repeat sale index are 3.97% and 21.67%, respectively; and based on corrected adjacent-period hedonic index are 1.72% and 15.52%, respectively.

3.2 Quantile Indices

The art markets are segmented across small investors and wealthy individuals and there are large deviations of prices for the high-end and low-end markets. The distribution of returns could be skewed and the pricing of hedonic characteristics varies across the distribution of auction prices. We investigate the variation of returns across price levels using quantile regression. Quantile regression is useful when the conditional distribution of the dependent variable is not symmetric.

We apply the quantile regression for every two-year period over 1957 to 2016 for the percentiles of 0.95, 0.75, 0.50, 0.25, and 0.05. We split our sample in subperiods to make sure that the quantile regression coefficients pick up variation in the valuation of hedonic attributes across price levels rather than across time and then link the coefficients on the time dummies for each quantile.

[Insert Table 5 and Figure 3 about here]

Figure 3 shows that there are large dispersions of the percentiles since 1957. Over our sample period, prices increase more in the higher quantiles. In addition, the higher quantiles are more volatile during the boom and bust periods. The higher the quantiles, the higher the average growth and volatility. For example, prices increased more during the mid-1980s boom and dropped more during the early-1990s bust for the higher quantiles such as Q95.

3.3 Indices by Art Media

We investigate the price indices of three subsamples of our data set: oil paintings, watercolors, and drawings (see Appendix II). The coefficients on the hedonic variables are in line with the baseline results.

We set the initial indices values as 100 in year 1957 and Figure 4 depicts the price trends for the oil paintings, watercolors, and drawings. Although the price trends are similar across different types of art, prices of oil paintings increase more than those of watercolors and drawings since 1970. Since the average prices by three art media are different, we normalize the initial indices values of watercolor and drawing price indices based on the five-year average prices from 1957 to 1961 relative to oil painting's and set oil painting index value in 1957 to be 100. Figure 5 shows that the price level of the oil paintings remains high over our sample period. The index of oil paintings reaches more than 900 in the late 1980s while the price trends of watercolors and drawings are less sensitive in the bubble and bust periods. Oil paintings are more volatile during the boom and bust periods, which is consistent with the quantile regression results of discrepancies across price levels in previous section.

[Insert Figure 4 and Figure 5 about here]

3.4 Indices by Art Movements

We match and classify artists into thirteen major movements in art history based on the biography information from Grove Art Online: (1) *Medieval & Renaissance*, (2) *Baroque*, (3) *Rococo*, (4) *Neoclassicism*, (5) *Romanticism*, (6) *Realism*, (7) *Impressionism & Symbolism*, (8) *Fauvism & Expressionism*, (9) *Cubism, Futurism & Constructivism*, (10) *Dada & Surrealism*, (11) *Abstract Expressionism*, (12) *Pop*, and (13) *Minimalism & Contemporary*.

In general, the results on the hedonic characteristics are in line with the earlier findings, although there is some variation in the coefficients on the topic dummies (e.g., a premium is paid for nudes and portraits only in *Pop*) and on the auction house dummies. R-square is above 70% for the movements of *Impressionism & Symbolism*; *Fauvism & Expressionism*; *Cubism, Futurism & Constructivism*; *Dada & Surrealism*; *Abstract Expressionism*; *Pop*; *Minimalism & Contemporary*, which indicates that we can explain the price level better for the more recent movements by hedonic model (see Online Appendix 1). As a robustness check, we select top 20 artists for each movement

by the price impact (magnitude of artists' coefficients) and the results are qualitatively similar (see Online Appendix 2).

For a clearer presentation, we group adjacent art movements into groups and define five art movement groups as: (1) *Medieval & Renaissance, Baroque, Rococo*, (2) *Neoclassicism, Romanticism, Realism*, (3) *Impressionism & Symbolism*, (4) *Fauvism & Expressionism, Cubism, Futurism & Constructivism, Dada & Surrealism*, (5) *Abstract Expressionism, Pop, Minimalism & Contemporary*. The regression results are reported in Appendix III. The price indices of movements are plotted in Figure 6 from 1957 onwards and indices initial values are set to be 100 in year 1957. Figure 6 shows that the price trends are similar across different movements. The prices of the latest movements group (5) *Abstract Expressionism, Pop, and Minimalism & Contemporary*, increase significantly more and are more volatile during the boom and bust periods. The price trends of group (3) *Impressionism & Symbolism* are similar to the trends of group (4) *Fauvism & Expressionism, Cubism, Futurism & Constructivism, and Dada & Surrealism*. The price trends of group (1) *Medieval & Renaissance, Baroque, and Rococo* are similar to those of group (2) *Neoclassicism, Romanticism, and Realism*.

[Insert Figure 6 about here]

Figure 7 shows the price levels of movements from 1957 to 2016. The initial index value of group (1) *Medieval & Renaissance, Baroque, Rococo* group is set to be 100 in year 1957. The initial indices values of other art movements groups are normalized by the average prices of the period from 1957 to 1961 relative to the *Medieval & Renaissance, Baroque, Rococo* group's. *Impressionism & Symbolism* has the highest price level from 1957 to the mid-2000s. However, in the mid-2000s bubble period, the price levels of *Abstract Expressionism, Pop, and Minimalism & Contemporary* reaches the price level of *Impressionism & Symbolism* and remained high after the bust. The art market has been growing more globally since 1970s and we have better coverage since then. As a robustness check, we repeat the hedonic regressions by 13 art movements and 5 art movements groups since 1970 and the results are reported in Online Appendix 3 and 4, respectively. Online Appendix 5 and 6 show graphically the price trends and levels of five art movements groups from 1970 and we have consistent results with Figure 6 and Figure 7.

[Insert Figure 7 about here]

The movements in art history revealed the changes of tastes over time. We investigate the changes of tastes by adding the interactions between topics and movements. The hedonic price regression results including the interactions of movements and topics are reported in Online Appendix 7. We are most interested in the marginal effects (interaction terms) of movements on topics, which indicate the most appreciated topics in each movement after controlling the absolute effects of topics and movements.

We find the topics of nude, study, and portrait in *Medieval & Renaissance*; still life, study, seascape, and portrait in *Baroque*; urbanscape and seascape in *Rococo*; seascape and portrait in *Neoclassicism*; seascape and study in *Romanticism*; still life and landscape in *Realism*; seascape and people in *Impressionism & Symbolism*; seascape and portrait in *Fauvism & Expressionism*; still life and religion in *Cubism, Futurism & Constructivism*; animal and people in *Dada & Surrealism*; study and abstract in *Abstract Expressionism*; nude and portrait in *Pop*; landscape and portrait in *Minimalism & Contemporary* are the most appreciated.

In addition, we investigate the interactions between nationalities and movements. The artists from original or popular countries of each movement may perform better than the artists from other countries in later auction markets. For example, French impressionists are much more appreciated comparing with impressionists of other origins in the markets. We follow the art history database Grove Art Online and define the country of origin (nationality) as the birth country ***and*** the living countries for artists. As reported in Online Appendix 8, we include the artist nationality dummies in thirteen subsamples of movements and exclude artist fixed effects while Online Appendix 9 presents the hedonic price regression results including the interactions of movements and artist nationalities while excluding artist control variables.

Both tables show that there exists a price premium for artworks made by artists coming from the birth places (original country or neighboring countries) of certain movements: *Medieval & Renaissance* artworks by German and French artists; *Baroque* artworks by Dutch, Belgian, and French artists; *Rococo* artworks by Spanish and Italian artists; *Neoclassicism* by French and Italian artists; *Romanticism* artworks by Russian, British, Dutch, and Belgian artists; *Realism* artworks by French and Spanish artists; *Impressionism & Symbolism* artworks by French and Spanish artists; *Fauvism &*

Expressionism artworks by Spanish, Russian, and German artists; *Cubism, Futurism & Constructivism* artworks by British and Spanish artists; *Dada & Surrealism* artworks by Italian, Spanish, Dutch, and Belgian artists; *Abstract Expressionism* artworks by Italian, Dutch, and Belgian artists; *Pop* artworks by French, American, and German artists; and *Minimalism & Contemporary* artworks by British, Dutch, and Belgian artists. This indicates the monetary appreciation of paintings made by artists from the matched origins of art movements.

3.5 Indices by Markets since 1970s

Art auction markets originated from Europe and the international markets gradually established after 1970. Renneboog and Spaenjers (2014) show that there is a close connection between the country of sale and the type (e.g., nationality) of artworks sold and the international demand differences play an important role in shaping the global art market. In this section, we investigate the market development in UK, USA and European continent since 1970. If the art markets are efficient, the price trends in different markets should converge and follow the law of one price (Pesando, 1993; Mei & Moses, 2002).

We classify the auction markets into three main subsamples: (1) UK, (2) USA, and (3) Continental Europe. The coefficients of hedonic variables are consistent across different markets (see Online Appendix 10).

[Insert Figure 8 and Figure 9 about here]

Figure 8 and Figure 9 present the price trends and price levels of British, American, and Continental European markets from 1970 onwards. In Figure 8 the initial indices values are set to be 100. In Figure 9, the initial index value for UK sales is set to be 100 in 1970 and the initial indices values for US and Europe sales are normalized by the average prices from 1970 to 1974 relative to UK's. Figure 8 shows that the price trends of the three markets are similar and the British market experienced the highest growth from 1970 to 2016. Figure 9 shows that the price levels of British and American markets are almost identical before early 1990s. The two markets reached the same price level during the first bubble period in mid-1980s. However, the price levels of British markets reached higher during the second bubble period in mid-2000s. The British and American markets are the largest and competing two markets over the sample period

while the European continental markets remained stable and relatively small over the sample period.

3.6 Indices by Auction Houses

The artworks sold at different auction houses and branches indicate the quality of the items and the tastes of the buyers. We investigate the price trends for the items sold at big and small auction houses. Since our observations are mainly sold in Christie's London or Sotheby's London and we have few observations in small auction houses before 1970, we start our subsamples in 1970. We classify auction houses into five subsamples: (1) Christie's and Sotheby's; (2) Bonhams and Phillips; (3) Important European Auction Houses; (4) Important American Auction Houses; and (5) Other Small Auction Houses.

The coefficients of basic hedonic variables are consistent with the baseline results. One interesting variation is that the authentication variable is not significant in Christie's, Sotheby's, Bonhams, and Phillips while the authentication variable has significant and positive effect on price for the subsamples of other auction houses. The authentication is less important for the big auction houses and the reputation of big auction houses can be a substitute for the authentication of artworks (see Online Appendix 11).

[Insert Figure 10 – Figure 11 about here]

Figure 10 shows the price trends of auction houses from 1970 to 2016. The price trends are similar across different auction houses while the big auction houses (Sotheby's, Christie's, Bonhams, and Phillips) are more sensitive during the bubble and bust periods. Sotheby's and Christie's lead the market growth before 2000 and Bonhams and Phillips lead the growth since 2000. Figure 11 shows the price levels of auction houses from 1970 to 2016. The initial index value for SC is set to be 100 in 1970 and the initial indices values for other auction houses are normalized by the average prices from 1970 to 1974 relative to SC's. Sotheby's and Christie's are the biggest two auction houses in auction markets and have much higher price levels comparing with other auction houses over the sample period. It's because these big auction houses are more selective in taking auction goods and sellers endogenously choose to sell high quality artworks via bigger auction houses.

3.7 Indices by Artist Nationalities

The styles of artists are influenced by the origins and cultures the artists experienced. The artworks from different countries reveal the histories and cultures of different areas. We investigate the price trends and levels of paintings created by artist from different nationalities. We run regressions on subsamples of artworks made by (1) British; (2) American; (3) Dutch & Belgian; (4) French; (5) German; (6) Italian; (7) Spanish; and (8) Russian artists. Online Appendix 12 shows that the magnitude and sign of hedonic variable coefficients are consistent with the baseline results.

Figure 12 presents the art price indices of British, American; French, Dutch & Belgian, and Spanish artists since 1957. The initial indices values are set to be 100 in year 1957. Figure 12 shows that artworks with different origins have similar price trends over the sample period. The Spanish arts are most volatile during the bubble and bust periods in 1990s and 2000s.

In Appendix VI, the initial index value for British artists is set to be 100 in 1957 and the initial indices values of artworks made by artists of other nationalities are normalized by the average prices from 1957 to 1961 relative to British artists'. The Spanish arts have the highest price levels in auction markets and French arts reached the second highest price levels. The British and American arts have lower price levels. One possible explanation is that the major auction markets concentrate in UK and USA and only the best quality arts from other countries can reach the major auction markets.

[Insert Figure 12 about here]

We also consider the new markets such as Chinese arts since 1970 (Online Appendix 13). The Chinese art markets has grown exponentially over the past few decades. We find that the geometric returns of Chinese arts reached above 9 % while other arts reached only about 1% from 1970 to 2016. As a robustness check, we repeat the figures starting from 1970 and find similar trends and levels for western artists (Online Appendix 14 and 15).

3.8 Indices by Local and International Markets

One interesting question is whether the paintings sold at international markets reached higher prices comparing with the ones sold at local markets. The popular artists

and items are more likely to be presented and sold at international markets, which can lead to higher prices realized in international auction markets. However, the paintings can reach higher price in local markets if the home bias exists. The buyers in local markets may have stronger preference for the works with same cultures and tastes.

We investigate the average price trends and levels of local and international markets. We have three definitions for local and international markets: (1) The observations are defined as Local when the artist nationality is the same as the sale country (Online Appendix 16, Figure 13, Appendix VII); (2) Since UK and US are the top two auction markets, it's unclear if a British (American) artists' work sold in UK (US) is driven by home bias or the artworks quality reach the international auction criteria. Therefore, we exclude British and American artists as a robustness check (Online Appendix 17, Figure 14, Appendix VIII); (3) As Sotheby's and Christie's London and New York City branches are the most renowned auction rooms, the best pieces of artworks from all over the world usually end up there. Therefore, we define International sale when the lots were sold at Sotheby's London, Sotheby's New York, Christie's London or Christie's New York (Online Appendix 18, Figure 15, Appendix IX).

[Insert Figure 13, Figure 14, and Figure 15 about here]

Figure 13 and Appendix VII show the price trends and price levels of local and international markets since 1957, respectively. Although both markets are experiencing similar trends, on average the international markets are more volatile than local markets. The price levels in international markets are about two- to three-fold of price levels in local markets.

Since the auction market distribution is skewed and mainly concentrate in UK and USA, all the items by British and American artists sold in the UK and USA will be defined as local sales although the sales in UK and USA are most likely to be internationally important sales especially in London and New York. Therefore, for the second market segmentation definition, we exclude the British and American artists (Figure 14 and Appendix VIII). For the third market segmentation definition we redefine the Sotheby's London, Sotheby's New York, Christie's London or Christie's New York as International markets (Figure 15 and Appendix IX). We again confirm that both markets experience same price trend while the price levels at international market is about five- to nine-fold of the price levels at local markets.

3.9 Artists' Life Cycle and Career Cycle

The life and career cycle of artistic creativity vary across movements and styles. The best paintings may be created in early or late periods of the artists. The artists may be old masters and the skills of artists become mature in late periods. The artists may also be young geniuses and the creativity of the artists spike in early periods. For example, experimental old masters such as Michelangelo, Rembrandt, Cézanne work by trial and error, and arrive at their major contributions gradually, late in life. In contrast, conceptual innovators and young geniuses such as Vermeer, van Gogh, Picasso make sudden breakthroughs by formulating new ideas, usually at an early age (Galenson (2011)).

We start with the price trends of life cycle of artistic creativity. We classify the artist life cycle into three subsamples by the ages when the artists created the paintings: (1) below (equal to) 30; (2) above 30 and below (equal to) 50; and (3) above 50. The regression results and price impacts are reported in Appendix IV. Appendix X shows that the price trends across creation ages are similar. To account for price level differences among the three age groups, the initial index value for below-30 group is set to be 100 in 1957 and the initial indices values for other age groups are normalized by the average price from 1957 to 1961 relative to below-30 group's in Appendix XI. The price levels on average are higher in the late stages (between 30 and 50 and above 50) in artists' life cycle. The appreciation of later artworks widens throughout the timeline in our sample.

Furthermore, we correct the uneven death age distribution among artists by classifying the artist career cycle into three subsamples by relative age of the artists: (1) Young, (2) Middle, and (3) Old. The auctioned lots are defined as (1) Young-age artworks if the artists created the art works below 18 or in the first one-third career phase after 18; defined as (2) Middle-age artworks if the artists created the art works during the middle one-third career phase after 18; defined as (3) Old-age artworks if the artists created the art works during the last one-third career phase after 18. Figure 16 and Figure 17 show that the paintings created in the relative late periods have highest price levels in auction markets since 1957. There's a clear pricing pattern that artworks created in later age on average demand a premium and outperform earlier artworks.

[Insert Figure 16 and Figure 17 about here]

4. Returns and Risks of Art Market

4.1 Returns and Risks Overview

Table 6 summaries an overview of art returns and risks whose regression results are detailed in Section 3. In Table 6 Panel A, we report annualized (as reported in both geometric mean and arithmetic mean) nominal returns, real returns, and repeat sale real returns in different holding periods: (1) sixty-year period from 1957 to 2016,[11] (2) first three decades of sample from 1957 to 1986, (3) the latter three decades of sample from 1987 to 2016, (4) bubble periods of 1985 to 1990 and of 2003 to 2007, (5) bust periods of 1991 to 1995 and of 2008 to 2010. We find that the arithmetic mean nominal return for the sixty year period is 6.24%, the arithmetic mean real return is 2.49%, and repeat sale real return is 3.97%. The annualized returns in the first three decades are significantly large while the art return is meager in the recent three decades if the financial returns are the only concerns for art investments. In the bubble periods, we observe a high annualized return between 13% to 18% in the 1985-1990 period and between 5% to 9% in the 2003-2007 periods. In the bust periods, the art annualized returns are all negative dipping to -5% per annum. Panel B reports return matrixes varying the starting year and ending year of the holding periods. Within each matrix subpanel, the column year denotes that the holding period starts on the 1-Jan of that year and the row year denotes that the holding period ends on the 31-Dec of that year. Holding the staring year constant, we observe a declining trend of art return for each starting years and the recent holding periods yield negative real returns. Panel C reports the volatility of art returns in both original and unsmoothed form. We apply the unsmoothing methodology to adjust the appraisal smoothing of return series (Geltner (1993)).[12] Over the 1957-2016 period, the standard deviation of unsmoothed art return in real term is 21.73% (instead of 16.21% in the original form) and the standard deviation of unsmoothed art return in nominal term is 21.88% (instead of 16.32% in the original form). The volatility in the first three decades in our sample is about one-third larger than the volatility in the recent three decades.

[11] In terms of holding period return, we denote, for example, 1957-2016 as the sixty-year holding period between 1-Jan-1957 to 31-Dec-2016.

[12] The art return series follows an AR(1) process using Ljung-Box Test. We set the appraisal smoothing factor α equal to the autocorrelation coefficient at lag 1 and the new series will then have a first-order autocorrelation that is close to zero.

Compared to prior studies in art returns, our return results in most cases are substantially lower. Goetzmann (1993), Pesando (1993), Mei and Moses (2002), and Korteweg, Kräussl, and Verwijmeren (2016) use repeat sale regression method to compute index returns while Renneboog and Spaenjers (2013) and Spaenjers, Goetzmann, and Mamonova (2015) reports hedonic index returns. Goetzmann (1993) documents that the annualized real return is 17.50% (a very selected high-end market) in the 1900-1986 period with a volatility of 52.80% in. Pesando (1993) documents an annualized real return of moderately 1.51% in the 1977-1992 period with a volatility of 19.94%. Mei and Moses (2002) reports an annualized real return of 4.90% in the 1875-1999 period with a volatility of 42.80%. Korteweg, Kräussl, and Verwijmeren (2016) corrects for sample selection and reports an annualized real return of 6.30% in the 1960-2013 period with a volatility of 11.40%. Among prior hedonic index returns, Renneboog and Spaenjers (2013) reports a (geometrically) annualized real return of 3.97% with a volatility of 15.21% in the 1957-2007 period. Spaenjers, Goetzmann, and Mamonova (2015) documents an annualized real return of 3.40% with a volatility of 15.20% in the 1900-2013 period.

4.2 Art Returns by Categories

In table 7 we report art annualized real return by 8 different categories (detailed in Section 3.2 to 3.8), namely by: (1) Dynamic Price Levels, (2) Art Media, (3) Art Movements, (4) Auction Markets, (5), Auction Houses Size, (6) Artists Nationalities, (7) Local vs International Market Segmentations, and (8) Artists' Life Cycle and Career Cycle.

We find a hierarchy in terms of real returns based on art price levels. The higher end art auction market (at 95 percentile) yields an arithmetic average real return of 2.23% while the lower end art auction market (at 5 percentile) yields only 1.46% in the sixty-year period from 1957 to 2016. Among the three common art media for paintings, oil paintings have the highest annualized real return (3.39%) compared to the return of watercolors (2.50%) and drawings (2.10%). Among all the thirteen art movements, artwork produced during the recent *Minimalism and Contemporary* movement has a whopping 17.70% annualized real return. *Pop* artworks (9.00%), *Neoclassicism* artworks (7.48%), and *Abstract Expressionism* artworks (6.22%) follow the hierarchy of annualized return in the sixty-year period. We further divide our sample into bubble periods (1985-1990 and 2003-2007) and bust periods (1991-1995 and 2008-2010). We

find that especially in the last bust period 2008-2010, *Minimalism and Contemporary*, *Pop*, and *Abstract Expressionism* artworks perform rather well with an annualized real return of -1.99%, 5.43%, and 1.32%, respectively (untabulated). Among the major art auction geographical markets, we spilt our samples into auctions taking places in UK, US, Continental EU auctions markets (further on into France and Germany markets).[13] UK auction houses transacts the highest real return of 3.26% in the 1970-2016 period while, on average, auction houses in other continent or countries yield meager real returns. Based on auction houses size, we split our samples into (1) Sotheby's & Christie's, (2) Bonhams & Phillips, (3) Important American Auction Houses, (4) Important European Auction Houses, and the rest (5) Small Auction Houses. We find that the Bonhams & Phillips yield the highest real return of 4.14% in the 1970-2016 period among all categories. To study the return effects of artist' domiciles (birth country or living country), we look into subsamples of artists who are (1) American, (2) Belgian, (3) British, (4) Dutch, (5) Dutch or Belgian, (6) French, (7) German, (8) Italian, (9) Russian, and (10) Spanish. We find that Russian and Spanish arts stand out with an annualized real return of 7.31% and 5.56%, respectively. We use three definitions of Local or International auction markets to see the performance differences between market segmentations: (1) The artworks are defined as Local sale when the artist nationality is the same as the sale country; (2) Since UK and US are the top two auction markets, it's unclear if a British (American) artists' work sold in UK (US) is driven by home bias or the artworks quality reach the international auction criteria. Therefore, we exclude British and American artists as a robustness check; (3) As Sotheby's and Christie's London and New York City branches are the most renowned auction rooms, the best pieces of artworks from all over the world usually end up there. Therefore, we define International sale when the lots were sold at Sotheby's London, Sotheby's New York, Christie's London or Christie's New York. The results are robust that the international auction markets uphold a higher real return comparted to local auction houses. The return gap is even larger in the latter two definitions which are 1.78% and 3.19%, respectively. Finally, we test if creation year will affect art returns by splitting artworks into three stages in artists life cycle and career cycle. We find that for deceased artists, the artworks, which are created in the last one-third stage of their life spans after

[13] Notice we start the sample from 1970 since UK was the dominating auction market before 1970s.

the age of 18, perform the best in the secondary market with an annualized real return of 4.08%.[14]

4.3 Comparisons with Other Art and Financial Assets

In table 8 we compare painting investment (as the focus in this paper) performance and correlations with other art investment vehicles and with financial assets. We collect investment indices and calculate real returns of stamps, red Bordeaux wines, classic cars, sculptures, and white diamonds from published articles. Stamps returns (in the 1900-2008 period) are calculated from Dimson and Spaenjers (2011); Red Bordeaux Wines returns (in the 1900-2012 period) are calculated from Dimson, Rousseau, and Spaenjers (2015); Classic cars returns (in the 1999-2017 period) are calculated from Laurs and Renneboog (2019); Sculptures returns (in the 1986-2013 period) are calculated from Vosilov (2015); and White Diamonds returns (in the 2000-2010 period) are calculated from Renneboog and Spaenjers (2012). Real returns of S&P 500, FTSE 100, Global Government Bond, Dow Jones, Corporate Bond, US AAA 10-year Corporate Bond, Goldman Sachs Commodity, and LME Gold are downloaded and calculated from Global Financial Data. US Housing real returns are obtained from Shiller (2015). T-bill rates downloaded from the website of Federal Reserve Bank of St. Louis is used as a proxy for risk-free rate. Due to data availability issues, we didn't replicate and expand the above-mentioned asset classes. Panel A and B report performance comparisons and Panel C reports pairwise correlation of painting investment and other art assets and financial assets.

Among alternative investment vehicles, we find that painting investment (2.49%) only outperforms sculpture investment (1.11%) while are still within similar range with stamp and classic car investments (3.57% and 3.37%, respectively). However red Bordeaux wines and white diamonds yield a much higher 6.71% and 5.79% annualized real returns, respectively. But this is noteworthy that our painting investment sample is less selective and the sample size is much larger covering low- and medium-end collectibles. We also calculate Sharpe Ratios for these alternative investment asset classes. Paintings have a -0.13 Sharpe Ratio, while Sculptures even lower (-0.17). For Stamps, Red Bordeaux Wines, Classic cars, and White Diamonds, the Sharpe Ratios

[14] Among three stages in artists' life cycle, we don't find differences in art real returns. This is due to the fact that living artists and deceased artists are pooled in the sample.

are 0.02, 0.20, 0.16, 0.31, respectively. In terms of return comovements, paining returns are strongly correlated with Sculptures (0.69) and White Diamonds (0.63), not very high with Classic cars (0.19), and close to zero (negative) with Red Bordeaux Wines (Stamps). All three-factor alphas for alternative investment vehicles are statistically insignificant from zero. This is probably due to poor model specification as supposing common factors in stock and bond markets are driving collectible market as well.

When compared to traditional financial assets, we find that stock market outperforms art market in real return but UK stock market is not really superior in terms of Sharpe ratio. The art real returns are similar to global government bond real returns while a bit lower than corporate bond investments. US housing and global commodity investment yield higher real return than paintings while paintings beat gold and treasure bill investments. Regarding three-factor alphas, stock, government bond, and global commodity markets exhibit significantly negative alphas while other financial assets' alphas are not statistically different from zero.

As to test the importance of paintings in portfolio optimization, we run a mean-variance optimization for portfolios including paintings. The risk-free rate is taken as the historic average of T-bill rate (0.88%) which is quite similar to the economic situation nowadays. The optimal portfolio assigns weights to Paintings, S&P 500 Stocks, US AAA 10-Yr Corporate Bond, and Gold as 7.58%, 26.38%, 50.02%, and 16.02%, respectively. The Sharpe ratio of this tangent portfolio is about 0.64.

5. Conclusion

In this paper we study the return and risks features of painting investment, which is the absolutely dominant vehicle within art investments, in a time frame of sixty years. We apply a detailed hedonic regression including artist, artwork, provenance, and transaction features as the pricing determinants. We find that the annualized real (nominal) return for painting is 2.49% (6.24%). Additionally, we run a three-stage weighted least-square repeat sales regression and an adjacent-period repeat sales regression and conclude that the real return for repeat sales subsample are 3.97% and 1.72%, respectively. The volatility of real (nominal) return is 16.21% (16.32%) while after adjustments of unsmoothing the volatility is 21.73% (21.88%).

We split our sample into two three-decade periods and find that the first 3 decades since 1957 yields much higher real return (6.23%) and unsmoothed volatility (24.62%)

compared to the real return (-1.38%) and unsmoothed volatility (17.41%) of the recent 3 decades since 1987. We reapply our baseline hedonic regression to different categories: by price level, by art media, by art movements, by art markets, by auction houses size, by artist nationalities, by market segmentations, and by artists' life and career cycles. We find that higher-end art market experience higher return and volatility; oil paintings outperform other art media; *Minimalism & Contemporary* art yields a whopping 17.70% annualized real return in the past 60 years followed by *Pop* art (9.00%), *Neoclassism* art (7.48%), and *Abstract Expressionism* art (6.22%) their performances are resilient in the recent financial crisis between 2008 and 2010; British auctioneers make a higher return compared to their peers in other continents; Bonhams and Phillips branches make the highest real return (4.14%) among auction houses of different sizes followed by Sotheby's and Christie's (2.91%); Spanish art has the highest price level and Russian and Spanish art have the highest real returns (7.31% and 5.56%, respectively); robust to various definition, the international auction markets perform better than the local auction markets; and for deceased artists, the artworks created in the last one-third stage since adulthood yield the highest real return (4.08%).

As compared to other minor investment vehicles in the collectible world, painting investment on average doesn't outperform in terms of real return and Sharpe Ratio. We reconcile that this is due to the fact that our data coverage on painting auction market is much boarder and covers low- and medium-end artworks. We find that painting investment exhibit strong positive correlations with sculpture and white diamonds investments, moderately with classic cars, and low (negative) with red Bordeaux wines (stamps).

Compared to traditional financial assets, we find that paintings' real returns are lower than stocks and bonds while paintings' Sharpe ratio is not always inferior; paintings' real returns are similar to global government bond and better than gold and treasury bills; paintings exhibit negative correlation with stock and bond markets and significantly strong correlation with global commodity and gold market; as for optimal portfolio, paintings receives about 7.6% weight in investments.

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Table 1 Descriptive Statistics for Hedonic Variables

This table presents the descriptive statistics for the hedonic variables. Deceased equals one in case the artist is dead at the time of the sale. The attribution dummies Attributed, Studio, Circle, School, After, and Style equal one if the auction catalogue identifies the work as being "Attributed to" the artist, from the "Studio" of that artist, from the "Circle" of the artist, from the artist's "School", "After" the artist, or "in the Style of" the artist, respectively. The authenticity dummies Signed, Dated, and Inscribed take the value of one if the work carries a signature of the artist or is Dated, Inscribed, respectively. The medium dummies Oil, Watercolor, and Drawing indicate whether the work is an Oil painting, a Watercolor, or a Drawing. The variables Height and Width measure the Height and the Width of the work in centimeters. The month dummies indicate the month of the sale. setting January as the benchmark The auction house dummies Sotheby's London, Sotheby's New York, Sotheby's Other Branches, Christie's London, Christie's New York, Christie's Other Branches, Bonhams London, Bonhams Other Branches, Phillips London, and Phillips New York equal one if the sale takes place at Sotheby's London, Sotheby's New York, another branches of Sotheby's, Christie's London, Christie's New York, other branches of Christie's, Bonhams London, other branches of Bonhams, Phillips London, or Phillips New York, respectively. Auction European and Auction American are dummy variables that equal one if the sale takes place at a large Continental European or a large American auction house, respectively (see Appendix). Pedigree, Exhibition, Literature, and Authentication are the dummy variables if the artworks have any information of Pedigree, Exhibition, Literature, and Authentication, respectively. For each variable, we report the number of observations (N), the mean, the standard deviation (S.D.), the minimum value, and the maximum value. For dummy variables, we also show the number of zeros and ones.

Variable	N	Mean	S.D.	Min	Max	Zeros	Ones
Artist Characteristics							
Deceased							
Deceased	2,257,485	0.82	0.38	0	1	400,275	1,857,210
Nationality							
American	2,257,485	0.12	0.32	0	1	1,992,743	264,742
Belgian	2,257,485	0.05	0.22	0	1	2,145,396	112,089
British	2,257,485	0.12	0.33	0	1	1,983,972	273,513
Dutch	2,257,485	0.06	0.23	0	1	2,127,080	130,405
French	2,257,485	0.19	0.39	0	1	1,825,448	432,037
German	2,257,485	0.07	0.26	0	1	2,092,074	165,411
Italian	2,257,485	0.10	0.30	0	1	2,031,322	226,163
Spanish	2,257,485	0.02	0.14	0	1	2,209,439	48,046
Russian	2,257,485	0.03	0.16	0	1	2,196,005	61,480
Art movement							
Medieval & Renaissance	2,257,485	0.03	0.16	0	1	2,221,303	36,182
Baroque	2,257,485	0.10	0.30	0	1	2,114,702	142,783
Rococo	2,257,485	0.03	0.16	0	1	2,222,455	35,030
Neoclassicism	2,257,485	0.01	0.11	0	1	2,241,977	15,508
Romanticism	2,257,485	0.04	0.19	0	1	2,206,502	50,983
Realism	2,257,485	0.05	0.23	0	1	2,183,064	74,421
Impressionism & Symbolism	2,257,485	0.09	0.28	0	1	2,139,245	118,240
Fauvism & Expressionism	2,257,485	0.07	0.25	0	1	2,166,029	91,456
Cubism, Futurism & Constructivism	2,257,485	0.05	0.21	0	1	2,194,546	62,939
Dada & Surrealism	2,257,485	0.05	0.21	0	1	2,193,581	63,904
Abstract Expressionism	2,257,485	0.04	0.19	0	1	2,207,380	50,105
Pop	2,257,485	0.02	0.14	0	1	2,229,929	27,556
Minimalism & Contemporary	2,257,485	0.02	0.15	0	1	2,225,816	31,669

Variable	N	Mean	S.D.	Min	Max	Zeros	Ones
Artwork Characteristics							
Attribution							
Attributed	2,257,485	0.03	0.18	0	1	2,183,618	73,867
Studio	2,257,485	0.00	0.05	0	1	2,250,680	6,805
Circle	2,257,485	0.01	0.11	0	1	2,230,423	27,062
School	2,257,485	0.00	0.06	0	1	2,250,258	7,227
After	2,257,485	0.01	0.08	0	1	2,244,403	13,082
Style	2,257,485	0.01	0.12	0	1	2,225,850	31,635
Authenticity							
Signed	2,257,485	0.71	0.46	0	1	664,818	1,592,667
Dated	2,257,485	0.35	0.48	0	1	1,460,129	797,356
Inscribed	2,257,485	0.13	0.34	0	1	1,960,319	297,166
Medium							
Oil	2,257,485	0.65	0.48	0	1	801,830	1,455,655
Watercolor	2,257,485	0.19	0.39	0	1	1,824,653	432,832
Drawing	2,257,485	0.16	0.37	0	1	1,888,487	368,998
Size							
Height	2,257,485	56.25	45.93	0	10,000	N/A	N/A
Width	2,257,485	58.37	50.30	0	13,550	N/A	N/A
Topic							
Abstract	2,257,485	0.03	0.16	0	1	2,198,752	58,733
Animals	2,257,485	0.05	0.21	0	1	2,148,812	108,673
Landscape	2,257,485	0.16	0.36	0	1	1,906,771	350,714
Seascape	2,257,485	0.04	0.20	0	1	2,161,727	95,758
Urbanscape	2,257,485	0.08	0.28	0	1	2,069,265	188,220
Nude	2,257,485	0.02	0.13	0	1	2,219,609	37,876
People	2,257,485	0.11	0.31	0	1	2,016,120	241,365
Self Portrait	2,257,485	0.00	0.06	0	1	2,249,033	8,452
Portrait	2,257,485	0.05	0.22	0	1	2,144,901	112,584
Religion	2,257,485	0.03	0.17	0	1	2,192,685	64,800
Still Life	2,257,485	0.06	0.23	0	1	2,129,170	128,315
Study	2,257,485	0.02	0.13	0	1	2,219,843	37,642
Other Topic	2,257,485	0.43	0.50	0	1	1,291,022	966,463
Provenance Characteristics							
Provenance							
Pedigree	2,257,485	0.14	0.35	0	1	1,940,934	316,551
Exhibition	2,257,485	0.05	0.21	0	1	2,155,999	101,486
Literature	2,257,485	0.05	0.21	0	1	2,150,698	106,787
Authentication	2,257,485	0.02	0.15	0	1	2,208,989	48,496
Transaction Characteristics							
Auction House							
Sotheby's London	2,257,485	0.07	0.26	0	1	2,098,623	158,862
Sotheby's New York	2,257,485	0.05	0.23	0	1	2,134,323	123,162
Sotheby's Other Branches	2,257,485	0.04	0.19	0	1	2,170,990	86,495
Christie's London	2,257,485	0.05	0.23	0	1	2,135,687	121,798
Christie's New York	2,257,485	0.04	0.20	0	1	2,166,595	90,890

Variable	N	Mean	S.D.	Min	Max	Zeros	Ones
Christie's Other Branches	2,257,485	0.07	0.25	0	1	2,101,912	155,573
Bonhams London	2,257,485	0.01	0.09	0	1	2,237,677	19,808
Bonhams Other Branches	2,257,485	0.02	0.16	0	1	2,201,933	55,552
Phillips London	2,257,485	0.01	0.09	0	1	2,237,718	19,767
Phillips New York	2,257,485	0.00	0.06	0	1	2,249,549	7,936
Auction American	2,257,485	0.03	0.16	0	1	2,199,371	58,114
Auction European	2,257,485	0.12	0.32	0	1	1,995,447	262,038
Month							
January	2,257,485	0.03	0.18	0	1	2,179,456	78,029
February	2,257,485	0.05	0.22	0	1	2,143,701	113,784
March	2,257,485	0.09	0.29	0	1	2,054,315	203,170
April	2,257,485	0.08	0.28	0	1	2,071,638	185,847
May	2,257,485	0.13	0.33	0	1	1,971,934	285,551
June	2,257,485	0.13	0.34	0	1	1,961,335	296,150
July	2,257,485	0.05	0.22	0	1	2,147,064	110,421
August	2,257,485	0.02	0.13	0	1	2,216,828	40,657
September	2,257,485	0.05	0.22	0	1	2,141,392	116,093
October	2,257,485	0.09	0.29	0	1	2,046,175	211,310
November	2,257,485	0.16	0.36	0	1	1,904,582	352,903
December	2,257,485	0.12	0.32	0	1	1,993,915	263,570

Hammer Price

Variable	N	Mean	S.D.	Median
Hammer Price (Nominal in US Dollars)				
Hammer Price	2,257,485	$ 46,696	$ 543,362	$ 3,952

Table 2 Baseline Hedonic Regression

This table presents the baseline hedonic regression results. Eq. (1) is estimated using OLS. The dependent variable is the natural log of hammer price deflated to 1957. Column (1) reports coefficients and Column (2) presents the price impact (i.e., the exponent of the estimated coefficient minus one). *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors are clustered at auction branch level and reported in parentheses.

Variables	(1) Coefficient	(2) Price Impact
Artist Characteristics		
Artist Characteristics		
Artist Fixed Effects	YES	
Deceased	0.1361*** (0.0216)	14.58%
Artwork Characteristics		
Attribution		
Attributed	-0.7343*** (0.0322)	-52.02%
Studio	-0.7227*** (0.0543)	-51.46%
Circle	-0.9934*** (0.0592)	-62.97%
School	-1.3643*** (0.1116)	-74.45%
After	-1.7525*** (0.0684)	-82.67%
Style	-1.5497*** (0.0637)	-78.77%
Authenticity		
Signed	0.1787*** (0.0189)	19.57%
Dated	0.1721*** (0.0075)	18.78%
Inscribed	-0.0083 (0.0096)	-0.83%
Medium		
Oil	1.2089*** (0.0175)	235.01%
Watercolor	0.4498*** (0.0159)	56.80%
Size		
Height	0.0060*** (0.0002)	0.60%
Width	0.0054*** (0.0002)	0.54%
Height_Sqr	-0.0001*** (0.0000)	-0.01%
Width_Sqr	-0.0001*** (0.0000)	-0.01%
Topic		
Abstract	0.0087 (0.0200)	0.87%
Animals	-0.0133 (0.0199)	-1.32%
Landscape	0.0327 (0.0295)	3.32%

Variables	(1) Coefficient	(2) Price Impact
Seascape	0.0850***	8.87%
	(0.0190)	
Urbanscape	0.1357***	14.53%
	(0.0161)	
Nude	-0.0739***	-7.12%
	(0.0209)	
People	0.0246	2.49%
	(0.0159)	
Self Portrait	0.1894***	20.85%
	(0.0289)	
Portrait	-0.1518***	-14.08%
	(0.0161)	
Religion	0.0098	0.98%
	(0.0227)	
Still Life	0.1025***	10.79%
	(0.0238)	
Study	-0.1606***	-14.84%
	(0.0153)	
Other Topic	0.1025***	10.78%
	(0.0254)	
Provenance Characteristics		
Provenance		
Pedigree	0.3138***	36.86%
	(0.0181)	
Exhibition	0.4037***	49.74%
	(0.0130)	
Literature	0.4453***	56.08%
	(0.0139)	
Authentication	0.1226***	13.03%
	(0.0304)	
Transaction Characteristics		
Auction House		
Sotheby's London	0.6529***	92.11%
	(0.0259)	
Sotheby's New York	0.6690***	95.25%
	(0.0353)	
Sotheby's Other Branches	0.3495***	41.84%
	(0.0401)	
Christie's London	0.6423***	90.08%
	(0.0271)	
Christie's New York	0.5163***	67.60%
	(0.0291)	
Christie's Other Branches	0.2057***	22.84%
	(0.0623)	
Bonhams London	0.3121***	36.63%
	(0.0279)	
Bonhams Other Branches	-0.0185	-1.83%
	(0.0674)	
Phillips London	0.2326***	26.19%
	(0.0249)	
Phillips New York	0.3160***	37.16%
	(0.0269)	
Auction_American	-0.1225***	-11.53%
	(0.0335)	
Auction_European	0.1593***	17.27%
	(0.0343)	

Variables	(1) Coefficient	(2) Price Impact
Month		
February	-0.0558	-5.43%
	(0.0634)	
March	0.0522	5.36%
	(0.0661)	
April	0.1127**	11.93%
	(0.0554)	
May	0.1840***	20.20%
	(0.0318)	
June	0.1469**	15.82%
	(0.0736)	
July	0.0895	9.36%
	(0.0862)	
August	-0.0336	-3.30%
	(0.0640)	
September	-0.0785	-7.54%
	(0.0658)	
October	0.0299	3.04%
	(0.0559)	
November	0.1741***	19.02%
	(0.0443)	
December	0.1477**	15.92%
	(0.0644)	
Year		
Year Fixed Effects	YES	
Constant	5.2586***	
	(0.1204)	
Observations	2,163,281	
R-squared	0.7301	

Table 3 Art Indices and Art Real Returns

This table presents the art price indices and real returns for the baseline hedonic regression model (Table 2). For each year, we report the estimated time dummy coefficient, the uncorrected price index and real return (Π and r), and the price index and real return that are corrected for changes in price dispersion over time (Π* and r*, see methodology, 2.1.1 Hedonic Model). This table also includes the repeat sale index and real returns over 1957 to 2016.

Year	Coefficient	Uncorrected Index	Uncorrected Return	Corrected Index	Corrected Return	Repeat Sale Index	Repeat Sale Return
1957		100.00		100.00		100.00	
1958	-0.1410	86.85	-13.15%	81.28	-18.72%	58.09	-41.91%
1959	0.1221	112.99	30.10%	108.19	33.11%	94.67	62.97%
1960	0.1788	119.58	5.83%	112.87	4.32%	82.07	-13.31%
1961	0.2217	124.82	4.38%	120.33	6.62%	153.49	87.02%
1962	0.2519	128.65	3.07%	123.00	2.21%	127.58	-16.88%
1963	0.5213	168.42	30.92%	155.04	26.05%	166.54	30.54%
1964	0.2730	131.39	-21.99%	123.69	-20.22%	119.73	-28.11%
1965	0.3932	148.17	12.77%	136.65	10.47%	148.66	24.16%
1966	0.5554	174.26	17.61%	148.41	8.61%	163.31	9.86%
1967	0.6695	195.33	12.09%	166.41	12.13%	164.19	0.54%
1968	0.8747	239.82	22.78%	222.15	33.50%	208.67	27.09%
1969	0.9323	254.03	5.93%	226.29	1.87%	228.08	9.30%
1970	0.8084	224.43	-11.65%	193.06	-14.69%	174.94	-23.30%
1971	1.0066	273.63	21.92%	230.33	19.30%	192.19	9.86%
1972	1.1665	321.07	17.34%	276.89	20.22%	233.24	21.36%
1973	1.4589	430.12	33.96%	366.65	32.42%	306.32	31.34%
1974	1.3880	400.68	-6.84%	337.62	-7.92%	281.77	-8.02%
1975	1.1501	315.85	-21.17%	262.10	-22.37%	219.13	-22.23%
1976	1.0139	275.63	-12.73%	226.82	-13.46%	193.27	-11.80%
1977	1.0217	277.79	0.78%	227.15	0.15%	190.79	-1.28%
1978	1.1758	324.07	16.66%	267.17	17.61%	217.72	14.12%
1979	1.2869	362.15	11.75%	293.97	10.03%	245.43	12.72%
1980	1.3010	367.30	1.42%	296.00	0.69%	264.33	7.70%
1981	1.1377	311.96	-15.07%	254.28	-14.09%	241.15	-8.77%
1982	0.9202	250.98	-19.55%	202.66	-20.30%	206.51	-14.36%
1983	0.9141	249.45	-0.61%	201.79	-0.43%	199.14	-3.57%
1984	0.9382	255.54	2.44%	212.32	5.22%	208.91	4.91%
1985	1.0164	276.32	8.13%	228.90	7.81%	242.21	15.94%
1986	1.2368	344.46	24.66%	285.13	24.56%	285.40	17.83%
1987	1.5707	481.00	39.64%	405.57	42.24%	407.39	42.75%
1988	1.7767	591.03	22.88%	493.82	21.76%	492.64	20.93%
1989	1.9904	731.85	23.83%	633.13	28.21%	638.76	29.66%
1990	2.0470	774.46	5.82%	662.17	4.59%	671.04	5.05%
1991	1.6449	518.05	-33.11%	410.82	-37.96%	413.37	-38.40%
1992	1.5219	458.09	-11.57%	361.37	-12.04%	337.73	-18.30%
1993	1.3547	387.56	-15.40%	309.40	-14.38%	294.63	-12.76%
1994	1.3338	379.54	-2.07%	308.57	-0.27%	295.40	0.26%
1995	1.3607	389.89	2.73%	315.80	2.34%	301.73	2.14%
1996	1.3520	386.51	-0.87%	312.06	-1.18%	312.53	3.58%
1997	1.2187	338.28	-12.48%	276.48	-11.40%	304.78	-2.48%
1998	1.1514	316.26	-6.51%	254.44	-7.97%	308.11	1.09%

Year	Coefficient	Uncorrected Index	Uncorrected Return	Corrected Index	Corrected Return	Repeat Sale Index	Repeat Sale Return
1999	1.2141	336.73	6.47%	270.29	6.23%	336.91	9.35%
2000	1.2060	334.01	-0.81%	271.62	0.49%	338.43	0.45%
2001	1.1275	308.79	-7.55%	253.55	-6.65%	322.80	-4.62%
2002	1.1691	321.91	4.25%	264.61	4.36%	329.52	2.08%
2003	1.2761	358.26	11.29%	291.12	10.02%	383.91	16.50%
2004	1.3783	396.82	10.76%	323.25	11.04%	420.12	9.43%
2005	1.3831	398.72	0.48%	327.87	1.43%	428.81	2.07%
2006	1.4521	427.21	7.14%	362.87	10.68%	522.49	21.85%
2007	1.7381	568.65	33.11%	428.75	18.15%	571.35	9.35%
2008	1.6068	498.68	-12.30%	383.66	-10.52%	475.47	-16.78%
2009	1.3720	394.32	-20.93%	296.42	-22.74%	413.39	-13.06%
2010	1.4110	410.01	3.98%	309.76	4.50%	407.90	-1.33%
2011	1.4518	427.08	4.16%	330.87	6.82%	441.00	8.11%
2012	1.2931	364.41	-14.67%	280.05	-15.36%	374.87	-14.99%
2013	1.2624	353.39	-3.02%	272.41	-2.73%	364.50	-2.77%
2014	1.1504	315.95	-10.60%	247.34	-9.20%	341.38	-6.34%
2015	1.0260	278.99	-11.70%	217.34	-12.13%	313.75	-8.09%
2016	0.9905	269.26	-3.49%	204.30	-6.00%	300.44	-4.24%
Arithmetic Mean Real Return			2.90%		2.49%		3.97%
Geometric Mean Real Return			1.69%		1.22%		1.88%
Volatility			15.91%		16.21%		21.67%

Table 4 Adjacent-period Regression Art Index and Art Real Return

This table presents the art price indices and real returns for the adjacent-period hedonic regressions. We run regressions for every two consecutive years and then link the coefficients on time dummies. For each year, we report the estimated time dummy coefficient, the price index and real return.

Year	Coefficient	Index	Return
1957		100.00	
1958	0.0239	102.42	2.42%
1959	0.2445	130.79	27.70%
1960	0.0246	134.04	2.49%
1961	0.0541	141.50	5.56%
1962	-0.0778	130.90	-7.49%
1963	0.2124	161.88	23.66%
1964	-0.3700	111.82	-30.93%
1965	0.0791	121.02	8.23%
1966	0.1460	140.05	15.72%
1967	0.1328	159.94	14.20%
1968	0.1272	181.63	13.56%
1969	-0.0014	181.38	-0.14%
1970	-0.3332	129.98	-28.34%
1971	0.1531	151.48	16.54%
1972	0.1746	180.38	19.08%
1973	0.2782	238.24	32.08%
1974	-0.1074	213.98	-10.18%
1975	-0.3003	158.47	-25.94%
1976	-0.1474	136.75	-13.71%
1977	0.0003	136.79	0.03%
1978	0.1562	159.92	16.91%
1979	0.128	181.76	13.66%
1980	0.0144	184.39	1.45%
1981	-0.1666	156.10	-15.35%
1982	-0.2247	124.68	-20.12%
1983	-0.0012	124.53	-0.12%
1984	0.0287	128.16	2.91%
1985	0.0885	140.02	9.25%
1986	0.2238	175.14	25.08%
1987	0.3296	243.51	39.04%
1988	0.1841	292.74	20.21%
1989	0.2139	362.55	23.85%
1990	0.0615	385.55	6.34%
1991	-0.3526	270.99	-29.71%
1992	-0.1055	243.85	-10.01%
1993	-0.1666	206.43	-15.35%
1994	-0.0084	204.71	-0.84%
1995	0.0017	205.05	0.17%
1996	-0.0065	203.72	-0.65%
1997	-0.0815	187.78	-7.83%
1998	-0.0543	177.86	-5.29%
1999	0.0535	187.63	5.50%
2000	-0.0016	187.33	-0.16%

Year	Coefficient	Index	Return
2001	-0.0721	174.30	-6.96%
2002	0.0582	184.74	5.99%
2003	0.1136	206.97	12.03%
2004	0.0920	226.91	9.64%
2005	0.0023	227.44	0.23%
2006	0.0688	243.63	7.12%
2007	0.1937	295.71	21.37%
2008	-0.1306	259.50	-12.24%
2009	-0.2119	209.95	-19.10%
2010	0.0413	218.80	4.22%
2011	0.0319	225.89	3.24%
2012	-0.1570	193.07	-14.53%
2013	-0.0275	187.84	-2.71%
2014	-0.1001	169.94	-9.53%
2015	-0.1324	148.87	-12.40%
2016	-0.0847	136.78	-8.12%
Arithmetic Mean Real Return			1.72%
Geometric Mean Real Return			0.53%
Volatility			15.52%

Table 5 Quantile Regression Art Indices

This table presents the art price indices and returns for the quantile regressions. We apply the quantile regression for every two-year period over 1957 to 2016 for the percentiles of 0.95, 0.75, 0.50, 0.25, and 0.05. We split our sample in subperiods to make sure that the quantile regression coefficients pick up variation in the valuation of hedonic attributes across price levels rather than across time and then link the coefficients on the time dummies for each quantile. For each year, we report the price index.

Year	Q05	Q25	Q50	Q75	Q95
1957	100.00	100.00	100.00	100.00	100.00
1958	100.88	101.58	102.33	103.29	104.22
1959	138.71	134.66	130.90	127.01	123.45
1960	151.06	142.26	134.22	126.28	119.18
1961	140.85	140.85	141.45	142.01	143.16
1962	135.81	133.12	131.14	128.54	126.28
1963	191.92	176.09	162.50	148.68	135.73
1964	111.23	111.26	112.16	112.41	112.14
1965	127.60	124.09	121.64	118.08	113.81
1966	154.03	146.73	140.95	133.70	125.73
1967	179.80	169.47	161.09	150.95	140.12
1968	183.90	182.32	182.14	181.00	179.28
1969	174.49	177.38	181.43	185.60	189.63
1970	126.36	127.76	130.03	132.31	134.42
1971	148.39	149.47	151.56	153.63	155.39
1972	166.40	172.75	180.22	188.42	197.68
1973	214.38	225.44	237.93	251.86	268.10
1974	198.34	205.36	213.74	223.04	233.45
1975	143.62	150.46	158.26	166.96	176.95
1976	125.17	130.46	136.60	143.39	151.09
1977	124.66	130.23	136.64	143.73	151.86
1978	140.14	149.44	159.65	171.09	185.02
1979	160.18	170.28	181.45	193.94	209.05
1980	160.59	171.81	184.04	197.80	214.73
1981	133.58	144.25	155.75	168.79	185.24
1982	108.13	115.94	124.42	134.02	145.88
1983	104.69	114.15	124.20	135.76	150.65
1984	103.66	115.41	127.71	142.15	161.61
1985	113.36	126.14	139.53	155.22	176.37
1986	142.02	157.90	174.54	194.02	220.25
1987	193.98	217.80	242.64	271.91	311.96
1988	232.77	261.61	291.68	327.13	375.69
1989	286.74	323.23	361.25	406.13	467.91
1990	304.74	343.63	384.16	431.98	497.89
1991	222.42	245.64	270.15	298.59	336.46
1992	199.65	220.80	243.08	268.99	303.53
1993	166.85	185.82	205.73	229.03	260.44
1994	162.04	182.50	203.93	229.29	264.14
1995	162.91	183.11	204.30	229.31	263.58
1996	163.59	182.80	203.01	226.76	258.93
1997	150.65	168.42	187.12	209.09	238.91
1998	144.86	160.62	177.30	196.74	222.62

Year	Q05	Q25	Q50	Q75	Q95
1999	152.44	169.27	187.05	207.80	235.49
2000	150.07	167.92	186.71	208.80	238.71
2001	137.59	155.19	173.69	195.52	225.58
2002	147.05	165.12	184.12	206.47	237.03
2003	167.60	186.41	206.31	229.56	260.83
2004	180.85	202.91	226.12	253.45	290.75
2005	182.98	204.21	226.66	253.00	288.61
2006	191.61	216.58	242.73	273.71	316.58
2007	223.74	258.05	294.53	338.41	399.52
2008	198.14	227.41	258.47	295.74	347.50
2009	160.10	183.88	209.11	239.41	281.48
2010	163.15	189.61	217.91	252.14	299.91
2011	170.59	196.93	224.97	258.78	305.75
2012	146.16	168.51	192.28	220.94	260.70
2013	140.61	163.08	187.09	216.08	256.51
2014	123.16	145.38	169.28	198.40	239.50
2015	109.48	128.22	148.28	172.62	206.82
2016	106.15	120.99	136.22	154.43	180.16
Arithmetic Mean Real Return	1.46%	1.58%	1.72%	1.92%	2.23%
Geometric Mean Real Return	0.10%	0.32%	0.53%	0.74%	1.00%
Volatility	16.54%	15.89%	15.52%	15.48%	15.93%

Table 6 Art Returns and Risks

This table presents art returns and risks features. Panel A reports the art annualized (both geometric and arithmetic mean) nominal return, real return, and repeat sale real return. The nominal return is calculated based on the corrected nominal hedonic indices (unreported) from OLS estimation by replacing the logarithm of nominal hammer price as dependent variable in Eq (1). Annualized real return and repeat sale return are calculated based on the corrected real return and repeat sale real return Table 3. In terms of holding period return, we denote, for example, 1957-2016 as the sixty-year holding period between 1-Jan-1957 to 31-Dec-2016. Panel B reports four subpanels of return matrixes containing nominal and real returns annualized as both geometric mean and arithmetic mean. The column year denotes that the holding period starts on the 1-Jan of that year and the row year denotes that the holding period ends on the 31-Dec of that year. Panel C reports volatility and unsmoothed volatility (see methodology, 2.1.2 Return Unsmoothing) of art nominal and real returns together with volatility of repeat sale real return.

Panel A: Art Annualized Nominal, Real, and Repeat Sale Real Returns

	Geometric Mean Return			Arithmetic Mean Return		
Holding Period	Nominal	Real	Repeat Sale	Nominal	Real	Repeat Sale
1957-2016	5.00%	1.22%	1.88%	6.24%	2.49%	3.97%
1957-1986	9.76%	4.78%	4.79%	11.05%	6.23%	7.88%
1987-2016	0.29%	-2.34%	-1.04%	1.26%	-1.38%	-0.08%
Bubble Period						
1985-1990	14.53%	10.24%	9.32%	18.10%	13.90%	12.97%
2003-2007	8.72%	5.68%	4.37%	9.22%	6.16%	5.18%
Bust Period						
1991-1995	-2.40%	-5.35%	-5.44%	-2.17%	-5.11%	-5.02%
2008-2010	-3.24%	-4.81%	-2.48%	-2.40%	-3.81%	-2.09%

Panel B: Art Return by Holding Periods

Nominal Return: Geometric Mean

	1958	1968	1978	1988	1998	2008
1968	9.25%					
1978	9.27%	11.15%				
1988	10.91%	12.70%	15.76%			
1998	6.85%	6.78%	5.73%	-0.08%		
2008	6.25%	6.06%	5.12%	1.65%	3.27%	
2016	5.00%	4.58%	3.44%	0.29%	0.58%	-6.25%

Real Return: Geometric Mean

	1958	1968	1978	1988	1998	2008
1968	7.04%					
1978	5.02%	4.86%				
1988	5.94%	6.26%	8.92%			
1998	2.40%	1.53%	0.79%	-3.33%		
2008	2.11%	1.38%	0.84%	-1.41%	0.58%	
2016	1.22%	0.42%	-0.27%	-2.34%	-1.58%	-7.91%

Nominal Return: Arithmetic Mean

	1958	1968	1978	1988	1998	2008
1968	10.58%					
1978	10.60%	12.50%				
1988	12.22%	13.99%	16.79%			
1998	8.30%	8.29%	7.23%	1.42%		
2008	7.56%	7.38%	6.36%	2.80%	3.89%	
2016	6.24%	5.81%	4.57%	1.26%	1.13%	-5.89%

Real Return: Arithmetic Mean

	1958	1968	1978	1988	1998	2008
1968	8.33%					
1978	6.42%	6.39%				
1988	7.40%	7.83%	10.28%			
1998	3.93%	3.13%	2.33%	-1.84%		
2008	3.48%	2.77%	2.11%	-0.26%	1.21%	
2016	2.49%	1.68%	0.86%	-1.38%	-1.03%	-7.48%

Panel C: Volatility and Unsmoothed (Adjusted) Volatility of Art Returns

Volatility of	**1957-2016**	**1957-1986**	**1987-2016**
Nominal Return	16.32%	17.16%	14.00%
Real Return	16.21%	17.79%	13.63%
Repeat Sale Real Return	21.67%	26.93%	13.71%
Unsmoothed Nominal Return	21.88%	24.13%	17.72%
Unsmoothed Real Return	21.73%	24.62%	17.41%

Table 7 Art Real Returns by Subsamples and Holding Periods

This table presents art annualized real returns calculated from the corrected hedonic indices by subsamples and holding periods. The subsamples are split by price levels (used in quantile regression); by art media; by art movements; by auction markets; by auction houses size; by artist nationalities; by market segmentations (local vs international market); by artists' life cycle and career cycle. The corresponding regression are reported in appendix. In terms of holding period return, we denote, for example, 1957-2016 as the sixty-year holding period between 1-Jan-1957 to 31-Dec-2016.

	Geometric Mean Real Return				Arithmetic Mean Real Return			
	1957-2016	1970-2016	1957-1986	1987-2016	1957-2016	1970-2016	1957-1986	1987-2016
Price Levels								
Q05	0.10%		2.23%	-2.06%	1.46%		4.21%	-1.38%
Q25	0.32%		2.63%	-2.01%	1.58%		4.36%	-1.30%
Q50	0.53%		3.00%	-1.97%	1.72%		4.56%	-1.23%
Q75	0.74%		3.39%	-1.93%	1.92%		4.87%	-1.14%
Q95	1.00%		3.87%	-1.88%	2.23%		5.39%	-1.03%
Media								
Oil painting	2.12%		5.89%	-1.65%	3.39%		7.27%	-0.63%
Watercolor	1.41%		4.83%	-2.01%	2.50%		6.15%	-1.27%
Drawing	0.38%		3.03%	-2.29%	2.10%		5.55%	-1.48%
Art Movements								
Medieval and Renaissance	1.41%		3.55%	-0.76%	3.32%		6.23%	0.31%
Baroque	2.00%		5.68%	-1.67%	3.42%		7.60%	-0.90%
Rococo	2.04%		5.52%	-1.44%	4.40%		9.01%	-0.37%
Neoclassicism	3.14%		9.42%	-2.98%	7.48%		16.51%	-1.87%
Romanticism	1.78%		5.88%	-2.30%	3.35%		7.97%	-1.43%
Realism	0.57%		3.68%	-2.55%	3.20%		7.83%	-1.58%
Impressionism and Symbolism	1.60%		6.12%	-2.86%	3.47%		8.62%	-1.85%
Fauvism and Expressionism	1.76%		5.98%	-2.42%	3.68%		8.56%	-1.37%
Cubism, Futurism, and Constructivism	2.87%		6.90%	-1.14%	4.74%		8.94%	0.39%
Dada and Surrealism	3.08%		7.85%	-1.63%	5.32%		10.66%	-0.21%

	Geometric Mean Real Return				Arithmetic Mean Real Return			
	1957-2016	1970-2016	1957-1986	1987-2016	1957-2016	1970-2016	1957-1986	1987-2016
Abstract Expressionism	3.43%		6.70%	0.14%	6.22%		10.06%	2.25%
Pop	2.79%		5.69%	-0.12%	9.00%		14.64%	3.17%
Minimalism and Contemporary	3.41%		5.87%	0.92%	17.70%		31.93%	2.98%
Auction Markets								
UK		1.88%		0.03%		3.26%		1.11%
USA		-0.60%		-2.06%		0.72%		-0.96%
Continental EU		-0.99%		-3.02%		0.20%		-2.06%
France		-1.78%		-4.14%		-0.13%		-2.84%
Germany		-0.83%		-2.46%		0.09%		-1.78%
Auction Houses Size								
Sotheby's & Christie's		1.67%		-0.30%		2.91%		0.71%
Bonhams & Phillips		2.67%		1.80%		4.14%		3.02%
American		-1.80%		-2.37%		-0.72%		-1.70%
European		-0.64%		-2.63%		0.58%		-1.65%
Small		-1.39%		-3.28%		-0.11%		-2.33%
Artist Nationalities								
American	2.25%		5.47%	-0.98%	4.38%		8.46%	0.16%
Belgian	1.93%		5.98%	-2.09%	3.38%		7.96%	-1.37%
British	1.64%		4.21%	-0.94%	2.87%		5.76%	-0.13%
Dutch	1.81%		5.93%	-2.28%	3.30%		7.99%	-1.54%
Dutch & Belgian	1.92%		5.99%	-2.12%	3.31%		7.88%	-1.41%
French	0.96%		5.37%	-3.40%	2.59%		7.21%	-2.18%
German	1.98%		5.55%	-1.58%	3.76%		8.11%	-0.75%
Italian	1.86%		5.10%	-1.39%	3.76%		7.62%	-0.24%
Russian	1.73%		4.66%	-1.22%	7.31%		13.36%	1.05%
Spanish	2.20%		6.26%	-1.83%	5.56%		10.76%	0.17%

	Geometric Mean Real Return				Arithmetic Mean Real Return			
	1957-2016	1970-2016	1957-1986	1987-2016	1957-2016	1970-2016	1957-1986	1987-2016
Market Segmentations (Local vs. International)								
Definition 1: Whole Sample, Local = 1 if Artist Nationality Matches Sale Country								
Local	1.31%		4.87%	-2.24%	2.37%		5.97%	-1.36%
International	1.93%		5.47%	-1.61%	3.37%		7.22%	-0.61%
Definition 2: Since1970, Excluding American and British Artists								
Local		-0.97%		-2.86%		0.25%		-1.88%
International		0.83%		-1.69%		2.03%		-0.72%
Definition 3: Since 1970, International = 1 if Auction Takes Place in Sotheby's or Christie's London or New York City								
Local		-0.86%		-2.42%		0.25%		-1.52%
International		2.03%		-0.09%		3.44%		1.12%
Life Cycle and Career Cycle								
0-30	1.71%		4.66%	-1.25%	3.71%		7.32%	-0.02%
30-50	2.21%		5.43%	-1.02%	3.78%		7.14%	0.29%
50+	2.17%		5.42%	-1.08%	3.56%		6.94%	0.05%
Young	1.60%		4.56%	-1.39%	3.36%		6.77%	-0.17%
Middle	2.12%		5.45%	-1.20%	3.57%		7.00%	0.03%
Old	2.60%		5.93%	-0.73%	4.08%		7.59%	0.46%

Table 8 Comparison of Investment Performance and Correlation with Other Assets

This table presents the comparison of art investment (painting investment as the focus in particular) performance with other art and financial assets as well as their correlations. Panel A reports the arithmetic mean of real return, return volatility, Sharpe ratio (calculated as the excess real returns divided by their standard deviation), and three-factor Alpha of art assets for art assets. Panel B reports the arithmetic mean of real return, return volatility, Sharpe ratio (calculated as the excess real returns divided by their standard deviation), and three-factor Alpha of art assets for paintings and other financial assets. For Alphas in Panel A and B, *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Panel C reports the pairwise correlation coefficients among art and financial assets. Coefficients in bold indicates statistical significance level of 5%. Stamps returns (in the 1900-2008 period) are calculated from Dimson and Spaenjers (2011); Red Bordeaux Wines returns (in the 1900-2012 period) are calculated from Dimson, Rousseau, and Spaenjers (2015); Classic cars returns (in the 1999-2017 period) are calculated from Laurs and Renneboog (2019); Sculptures returns (in the 1986-2013 period) are calculated from Vosilov (2015); and White Diamonds returns (in the 2000-2010 period) are calculated from Renneboog and Spaenjers (2012). Real returns of S&P 500, FTSE 100, Global Government Bond, Dow Jones, Corporate Bond, US AAA 10-year Corporate Bond, Goldman Sachs Commodity, and LME Gold are downloaded and calculated from Global Financial Data. US Housing real returns are obtained from Shiller (2015). T-bill rates downloaded from the website of Federal Reserve Bank of St. Louis is used as a proxy for risk-free rate. MKT, SMB, and HML factors are downloaded from K. French's website.

Panel A: Comparison of Investment Performance with Other Art Assets

Asset Class	Paintings	Stamps	Red Bordeaux Wines	Classic cars	Sculptures	White Diamonds
Return Period	1958-2016	1900-2008	1900-2012	1999-2017	1986-2013	2000-2010
Real Return	2.49%	3.57%	6.71%	3.37%	1.11%	5.79%
Volatility	16.21%	12.50%	26.26%	10.03%	15.01%	10.98%
Sharpe Ratio	-0.13	0.02	0.20	0.16	-0.17	0.31
Alpha	0.00	0.01	0.02	0.04	-0.03	0.08

Panel B: Comparison of Investment Performance with Other Financial Assets

Asset Class	Paintings	S&P 500 Stock	FTSE 100 Stock	Global Govt. Bond	Dow Jones Corp. Bond	US AAA 10-Yr Corp. Bond	Goldman Sachs Commodity	LME Gold	US Housing	T-Bill
Return Period	1958-2016	1958-2016	1979-2016	1958-2016	1958-2016	1958-2016	1970-2016	1958-2016	1958-2016	1958-2016
Real Return	2.49%	7.84%	3.73%	2.98%	4.49%	3.07%	3.81%	1.34%	4.25%	0.88%
Volatility	16.21%	16.82%	13.82%	7.76%	9.17%	9.95%	8.00%	21.66%	21.44%	2.24%
Sharpe Ratio	-0.13	0.18	-0.07	-0.20	-0.01	-0.15	-0.09	-0.16	-0.02	-
Alpha	0.00	-0.04***	-0.08***	-0.03**	-0.02*	-0.02	-0.02*	-0.02	0.03	-

Panel C: Pairwise Correlation of Art and Financial Assets

	Paintings	Stamps	Red Bordeaux Wines	Classic Cars	Sculpt.	White Diamonds	S&P 500 Stock	FTSE 100 Stock	Global Govt. Bond	Dow Jones Corp. Bond	US AAA 10-Yr Corp. Bond	GS Commodity	LME Gold	US Housing	T-Bill
Paintings	1.00														
Stamps	-0.02	1.00													
Red Bordeaux Wines	0.01	-0.04	1.00												
Classic cars	0.19	0.21	0.09	1.00											
Sculptures	**0.69**	-0.17	0.19	0.17	1.00										
White Diamonds	**0.63**	-0.12	-0.08	0.47	0.39	1.00									
S&P 500 Stock	-0.11	-0.24	0.15	-0.03	0.18	0.17	1.00								
FTSE 100 Stock	-0.03	**-0.38**	0.25	-0.03	0.23	0.26	**0.83**	1.00							
Global Govt. Bond	-0.10	**-0.35**	-0.02	-0.23	0.10	-0.26	**0.33**	0.24	1.00						
Dow Jones Corporate Bond	-0.23	**-0.30**	0.10	**-0.52**	-0.10	**-0.81**	**0.37**	0.31	**0.87**	1.00					
US AAA 10-Yr Corporate Bond	-0.18	-0.24	-0.09	-0.01	-0.18	-0.08	0.08	-0.02	**0.77**	**0.79**	1.00				
Goldman Sachs Commodity	-0.21	**-0.32**	0.03	-0.22	-0.20	-0.25	0.22	0.10	**0.80**	**0.89**	**0.92**	1.00			
LME Gold	**0.40**	-0.03	0.27	-0.02	**0.38**	-0.03	-0.04	0.21	-0.10	-0.17	**-0.32**	**-0.32**	1.00		
US Housing	**0.32**	**0.31**	-0.03	-0.23	0.24	0.37	-0.25	-0.11	-0.10	-0.24	-0.18	**-0.28**	**0.45**	1.00	
T-Bill	0.09	0.08	0.12	0.26	0.21	-0.07	0.17	0.19	0.11	0.05	-0.07	0.05	0.03	-0.11	1.00

Figure 1 Baseline Price Indices since 1957 (Indices Initial Values = 100)

This figure presents the baseline art price indices since 1957 detailed in Table 3. The initial index values are set to 100 in year 1957 for all three methods.

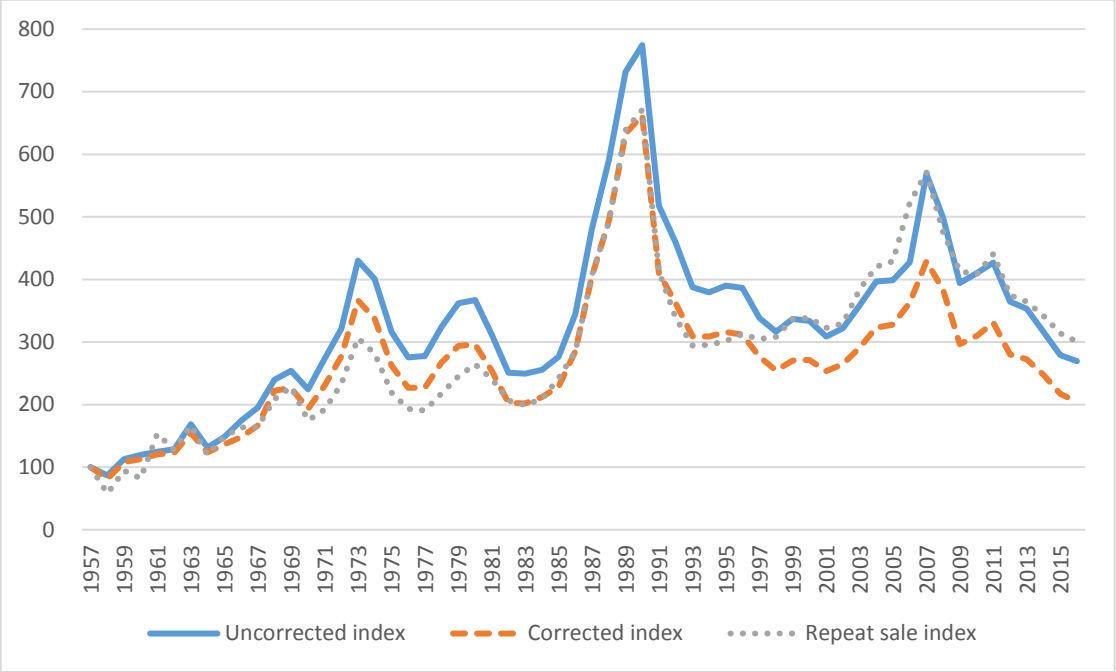


Figure 2 Adjacent-period Hedonic Price Index since 1957 (Index Initial Value = 100)

This figure presents the baseline art price indices since 1957 detailed in Table 4. The initial index value is set to 100 in year 1957.

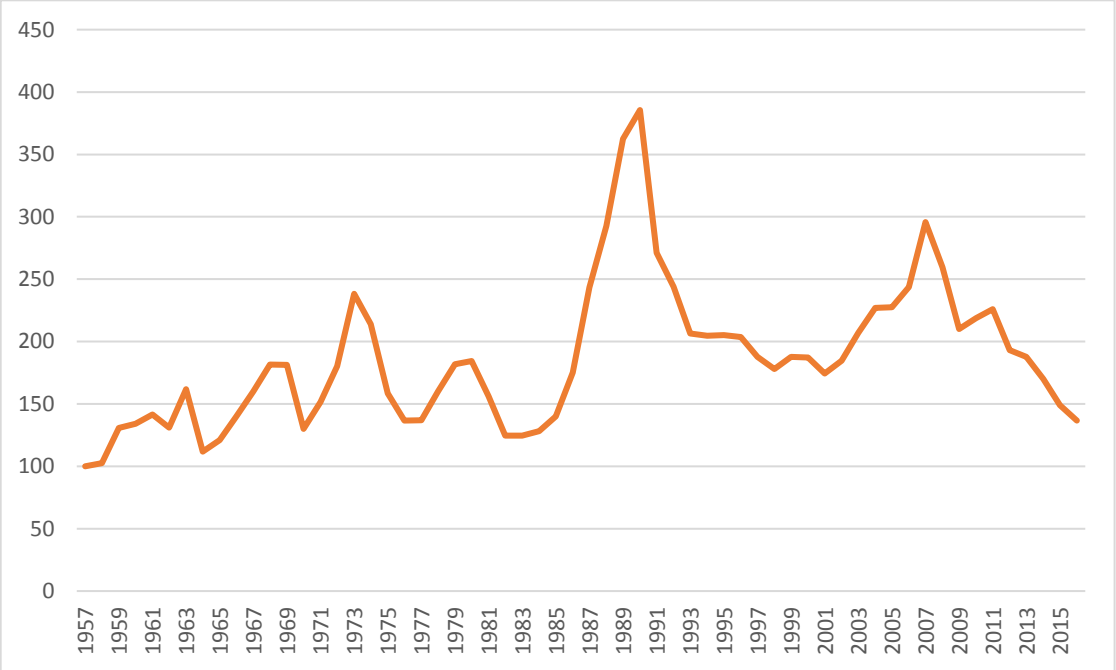


Figure 3 Quantile Price Indices since 1957 (Indices Initial Values = 100)

This figure presents the art price indices since 1957 that result from quantile regressions detailed in Table 5 for the percentiles of 0.95, 0.75, 0.50, 0.25, and 0.05. The initial index values are set to 100 in year 1957 for all groups.

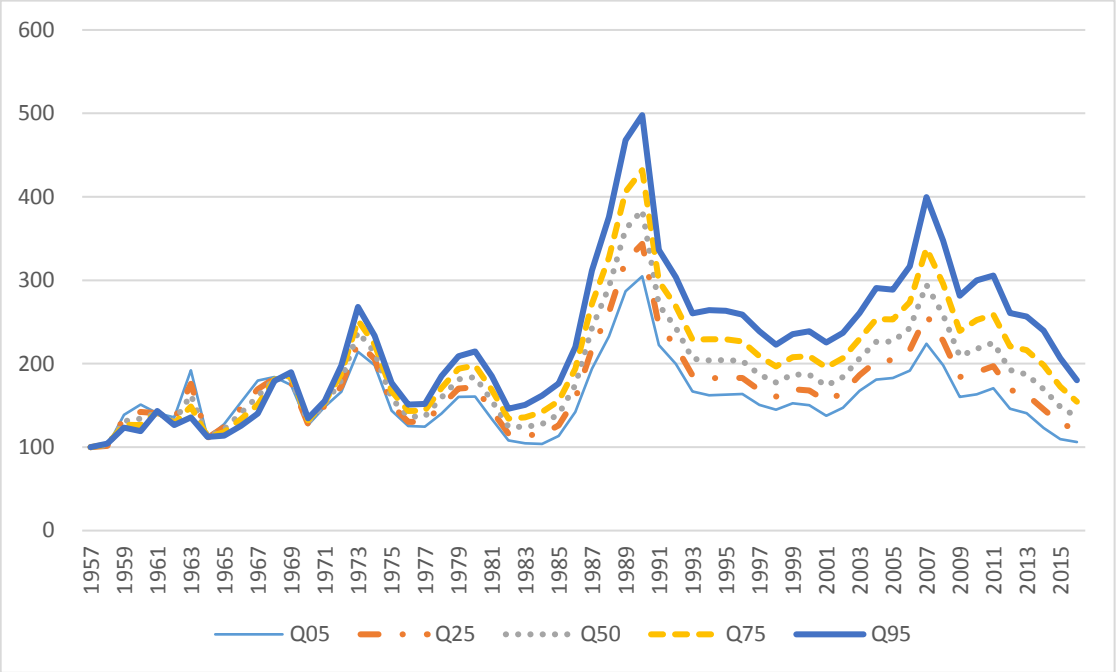


Figure 4 Price Indices of Oil paintings, Watercolors, and Drawings since 1957 (Indices Initial Values = 100)

This figure presents the art price indices of Oil paintings, Watercolors, and Drawings detailed in Appendix II. The initial index values are set to 100 in year 1957 for all three media.

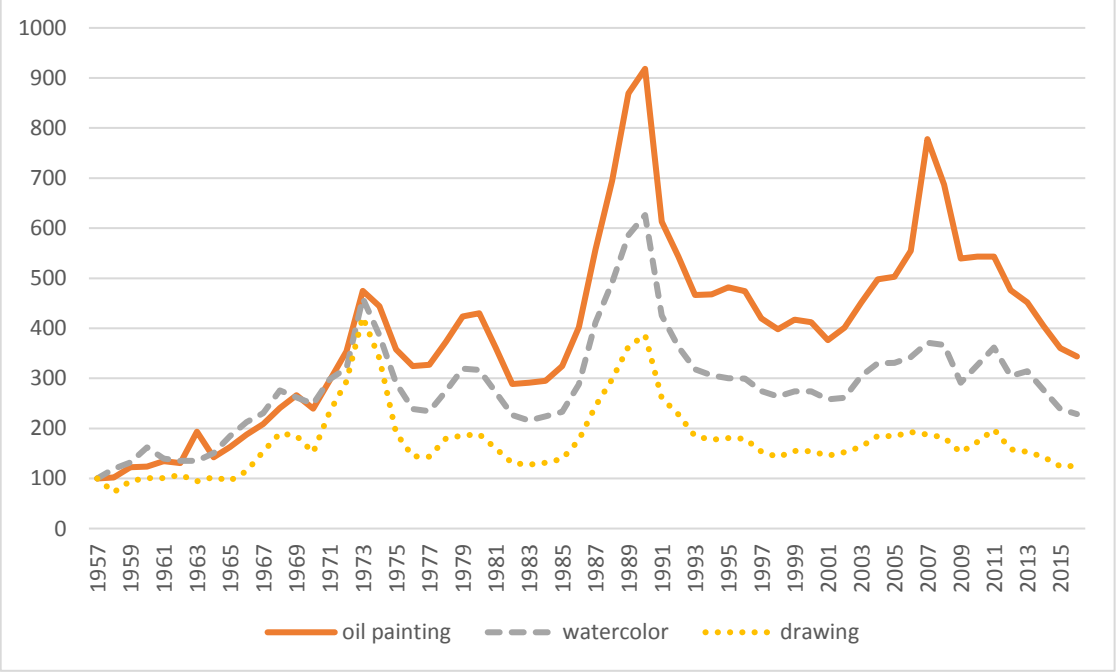


Figure 5 Price Indices of Oil paintings, Watercolors, and Drawings since 1957 (Relative Indices Initial Values)

This figure presents the art price indices of Oil paintings, Watercolors, and Drawings since 1957 detailed in Appendix II. Oil painting index value in 1957 is set to be 100. The initial index values of Watercolor and Drawing indices are normalized based on the five-year average price from 1957 to 1961 relative to Oil painting's.

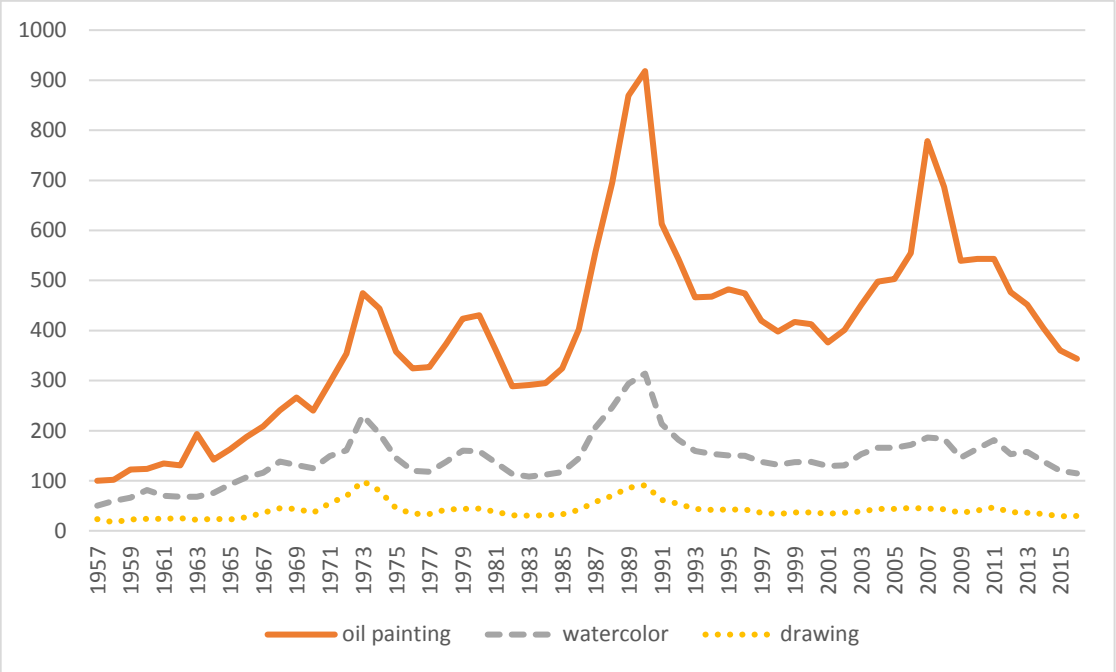


Figure 6 Price Indices of Art Movements since 1957 (Indices Initial Values = 100)

This figure presents the art price indices of movements since 1957 detailed in Appendix III. We classify artists into 5 groups: (1) Medieval & Renaissance, Baroque, Rococo; (2) Neoclassicism, Romanticism, Realism; and (3) Impressionism & Symbolism; (4) Fauvism & Expressionism, Cubism, Futurism & Constructivism, Dada & Surrealism; (5) Abstract Expressionism, Pop, Minimalism & Contemporary. The initial values of all indices are set to be 100 in year 1957.

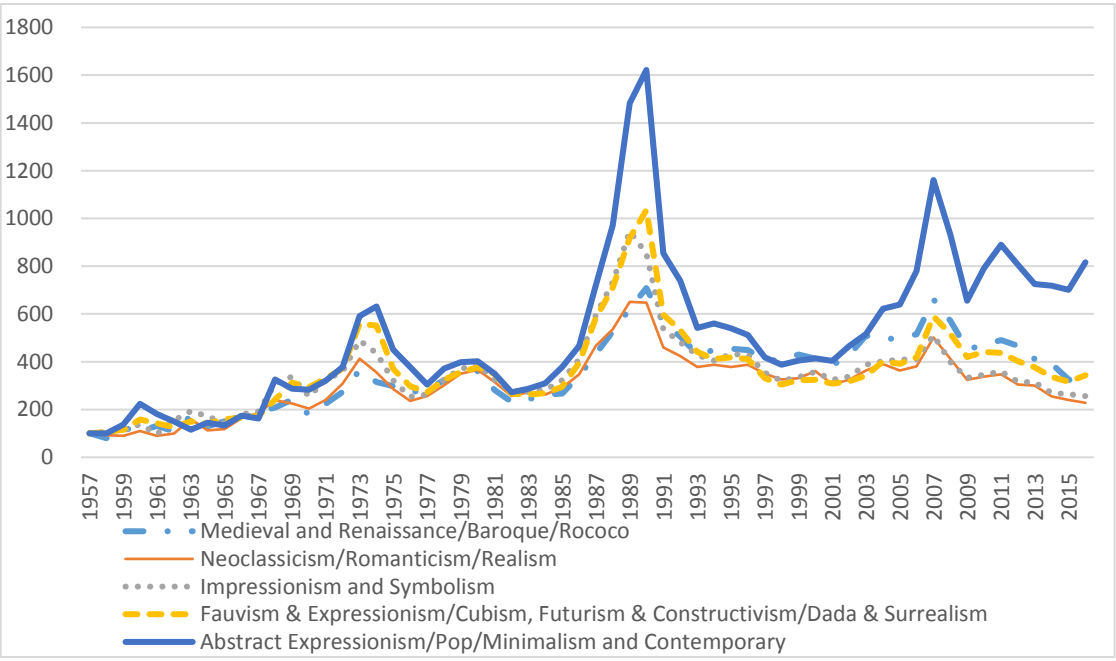


Figure 7 Price Indices of Art Movements since 1957 (Relative Initial Indices Values)

This figure presents the art price indices of movements since 1957 detailed in Appendix III. We classify artists into 5 groups: (1) Medieval & Renaissance, Baroque, Rococo; (2) Neoclassicism, Romanticism, Realism; and (3) Impressionism & Symbolism; (4) Fauvism & Expressionism, Cubism, Futurism & Constructivism, Dada & Surrealism; (5) Abstract Expressionism, Pop, Minimalism & Contemporary. The initial index value of Medieval & Renaissance, Baroque, Rococo group is set to be 100 in year 1957. The initial indices values of other art movements groups are normalized by the average price of the period from 1957 to 1961 relative to the Medieval & Renaissance, Baroque, Rococo group's.

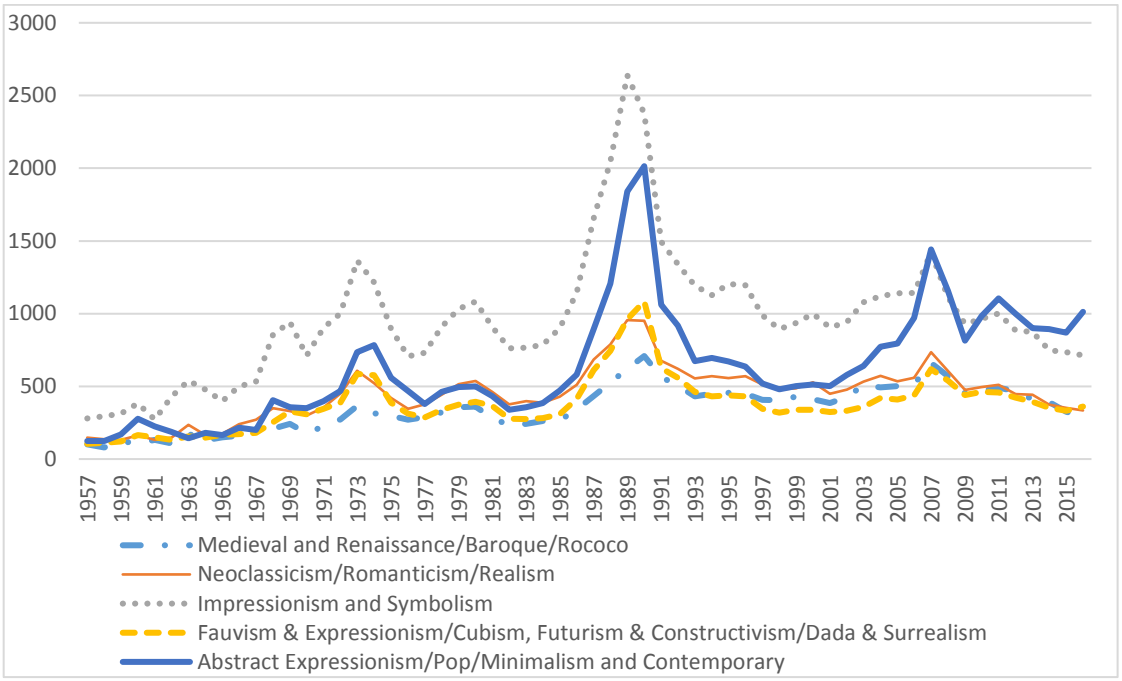


Figure 8 Price Indices of Auction Markets since 1970 (Indices Initial Values = 100)

This figure presents the art price indices of auction markets including UK, USA and European continent since 1970 detailed in Online Appendix 10. The initial indices values are set to be 100 in year 1970.

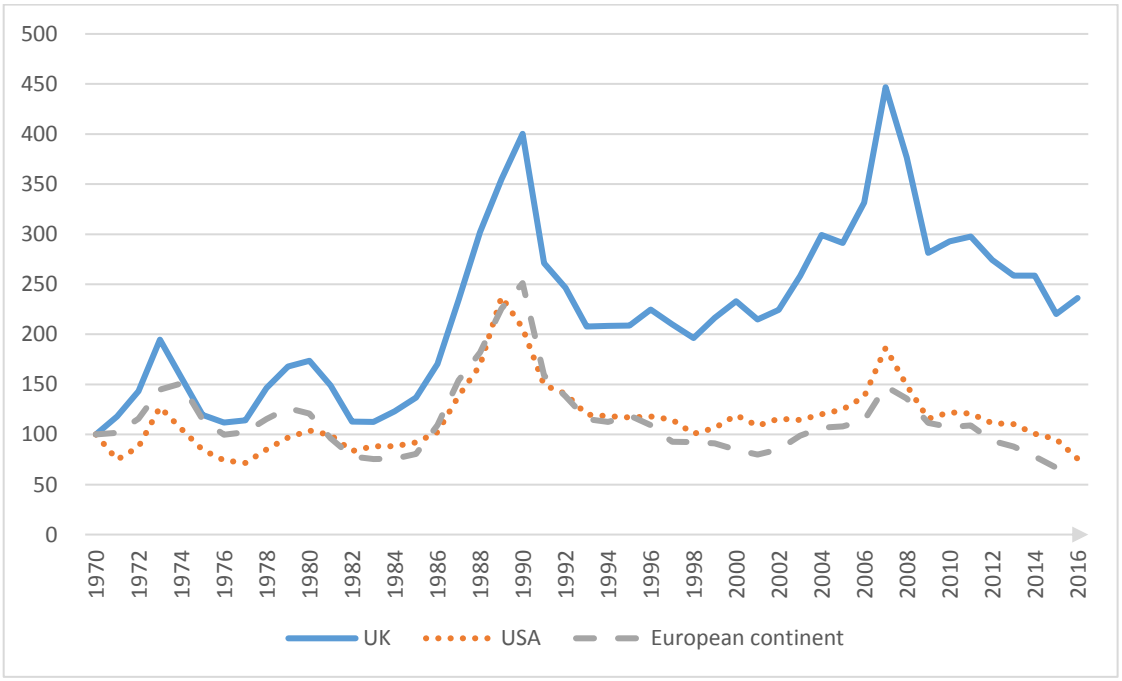


Figure 9 Price Indices of Auction Markets since 1970 (Relative Initial Indices Values)

This figure presents the art price indices of auction markets including UK, USA and European continent since 1970 detailed in Online Appendix 10. The initial index value for UK sales is set to be 100 in 1970 and the initial indices values for US and Europe sales are normalized by the average prices from 1970 to 1974 relative to UK's.

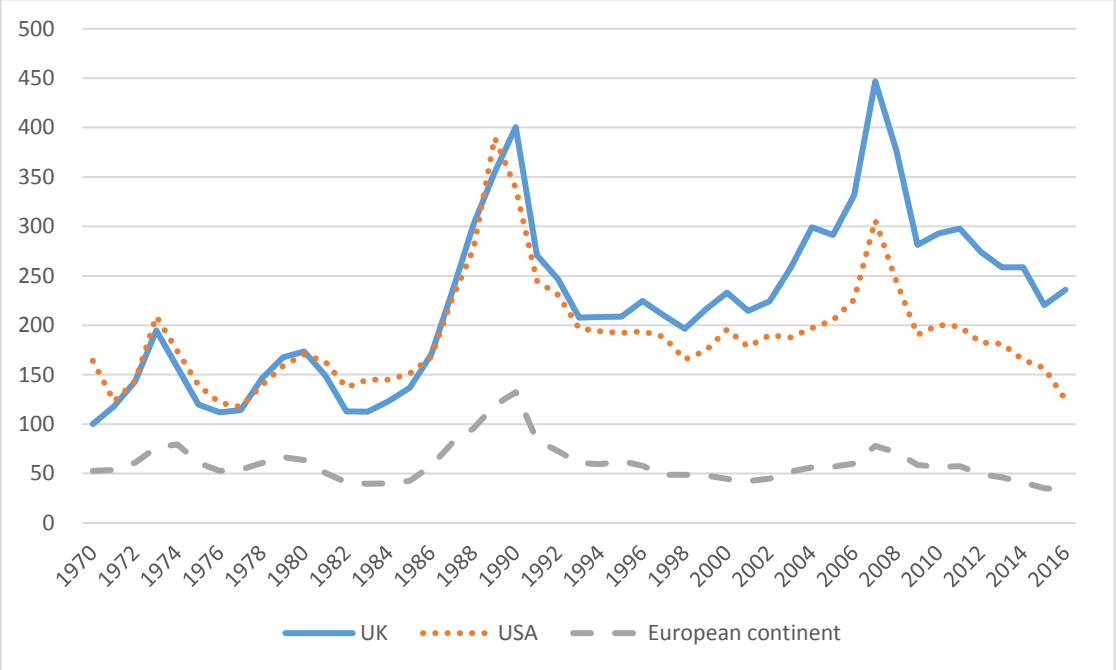


Figure 10 Price Indices of Auction Houses since 1970 (Indices Initial Values = 100)

This figure presents the art price indices of auction houses including (1) Christie's and Sotheby's (SC); (2) Bonhams and Phillips (BP); and (3) Important European Auction Houses (European); (4) Important American Auction Houses (American); (5) Other Small Auction Houses (Small) since 1970 detailed in Online Appendix 11. The initial indices values are set to be 100 in year 1970.

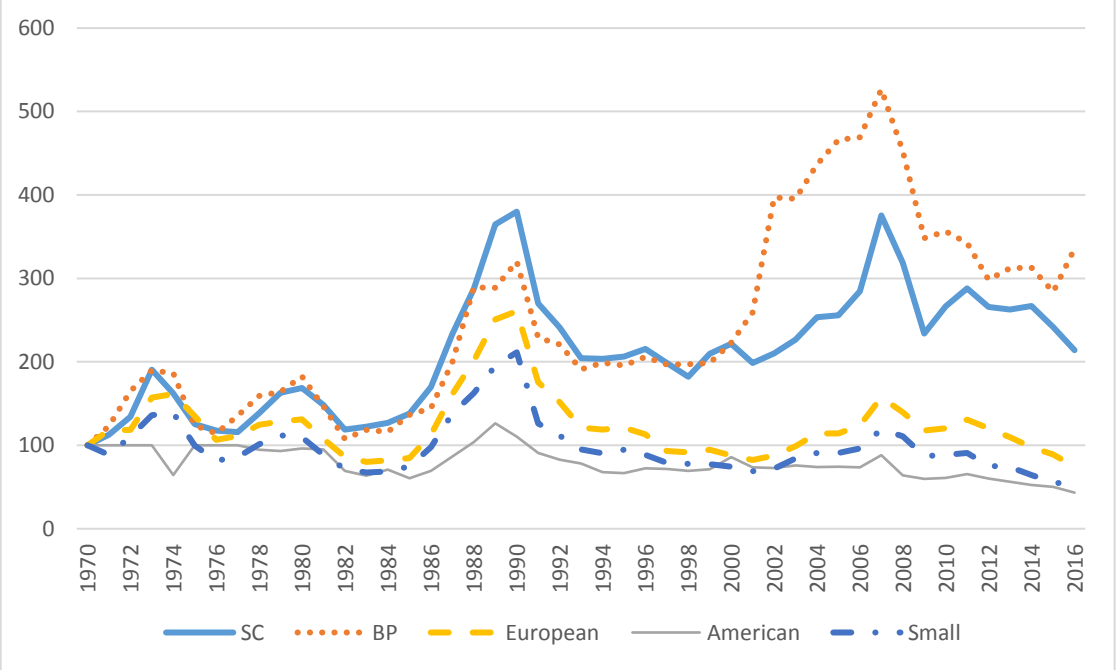


Figure 11 Price Indices of Auction Houses since 1970 (Relative Indices Initial Values)
This figure presents the art price indices of auction houses including (1) Christie's and Sotheby's (SC); (2) Bonhams and Phillips (BP); and (3) Important European Auction Houses (European); (4) Important American Auction Houses (American); (5) Other Small Auction Houses (Small) since 1970 detailed in Online Appendix 11. The initial index value for SC is set to be 100 in 1970 and the initial indices values for other auction houses are normalized by the average prices from 1970 to 1974 relative to SC's.

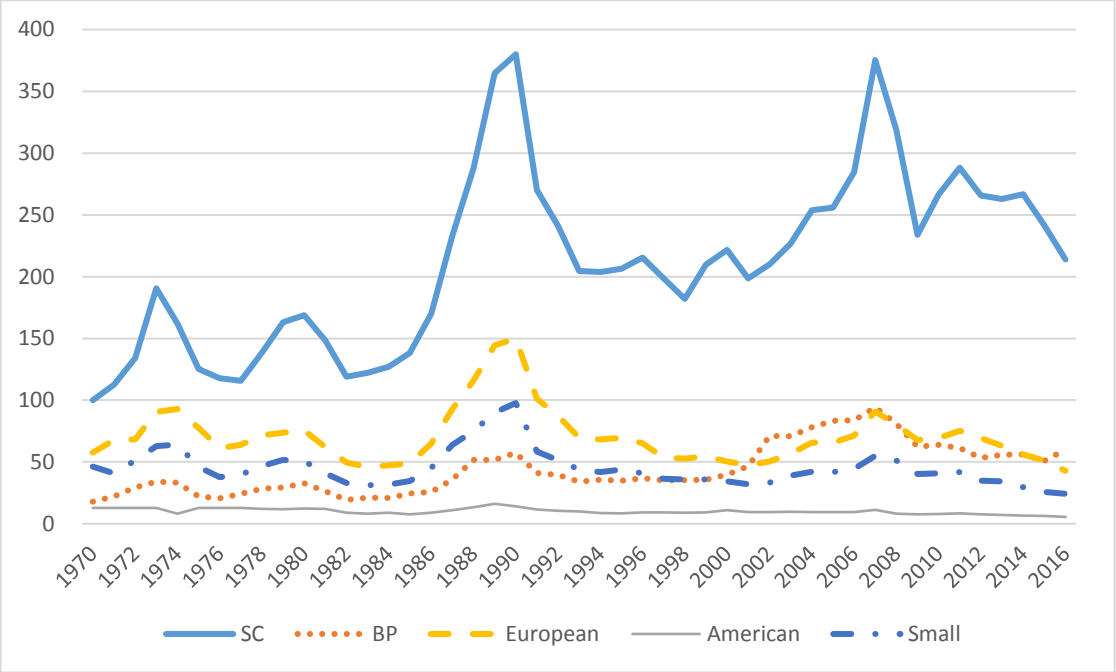


Figure 12 Price Indices of Artist Nationalities since 1957 (Indices Initial Values = 100)
This figure presents the art price indices of British, American; French, Dutch & Belgian, and Spanish artists since 1957 detailed in Online Appendix 12. The initial indices values are set to be 100 in year 1957.

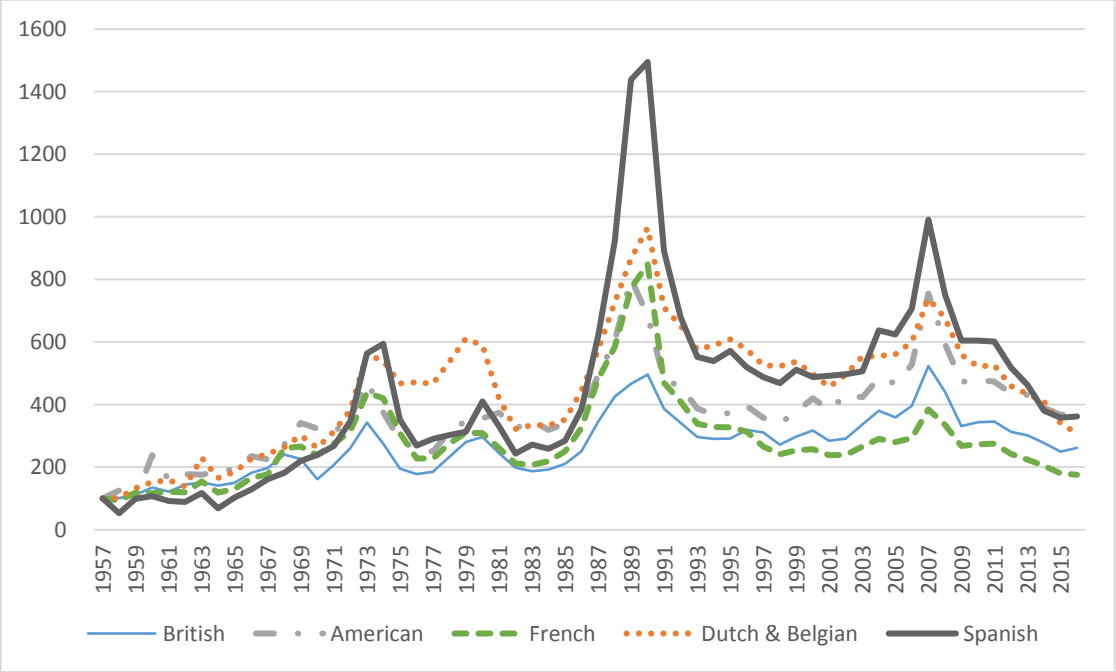


Figure 13 Price Indices of Local and International Markets since 1957 (Indices Initial Values = 100)

This figure presents the art price indices of local and international markets since 1957 detailed in Online Appendix 16. The observations are defined as Local when the artist nationality is the same as the sale country. The observations are defined as International when the artist nationality is different from the sale country. The initial indices values are set to be 100 in year 1957.

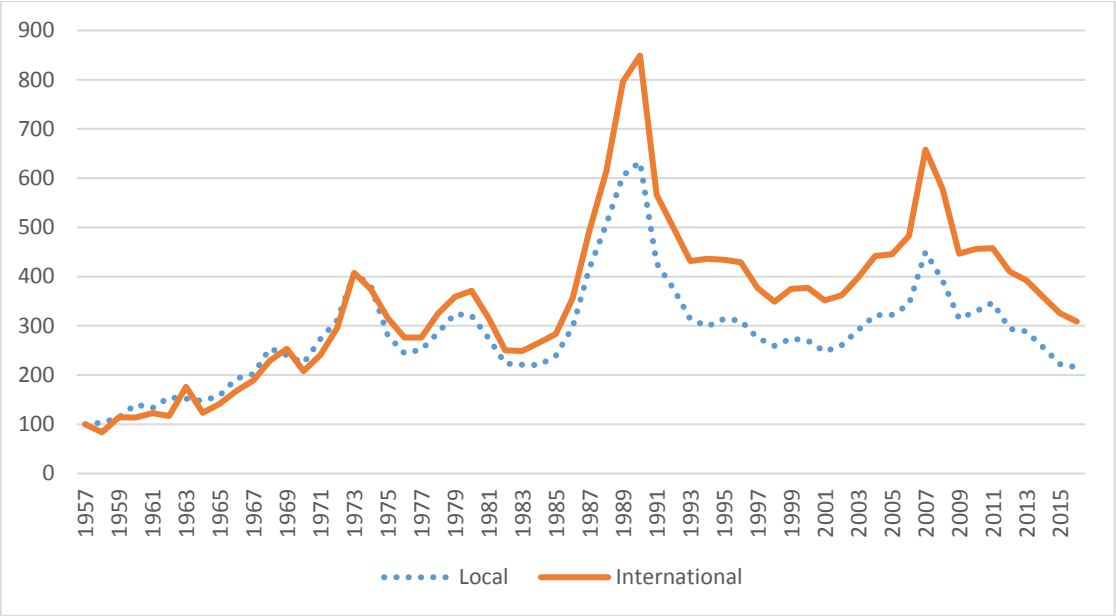


Figure 14 Price Indices of Local and International Markets since 1970 (Excluding British and American Artists, Indices Initial Values = 100)

This figure presents the art price indices of local and international markets excluding British and American artists since 1970 detailed in Online Appendix 17. The observations are defined as Local when the artist nationality (excluding British and American artists) is the same as the sale country. The observations are defined as International when the artist nationality (excluding British and American artists) is different from the sale country. The initial indices values are set to be 100 in year 1970.

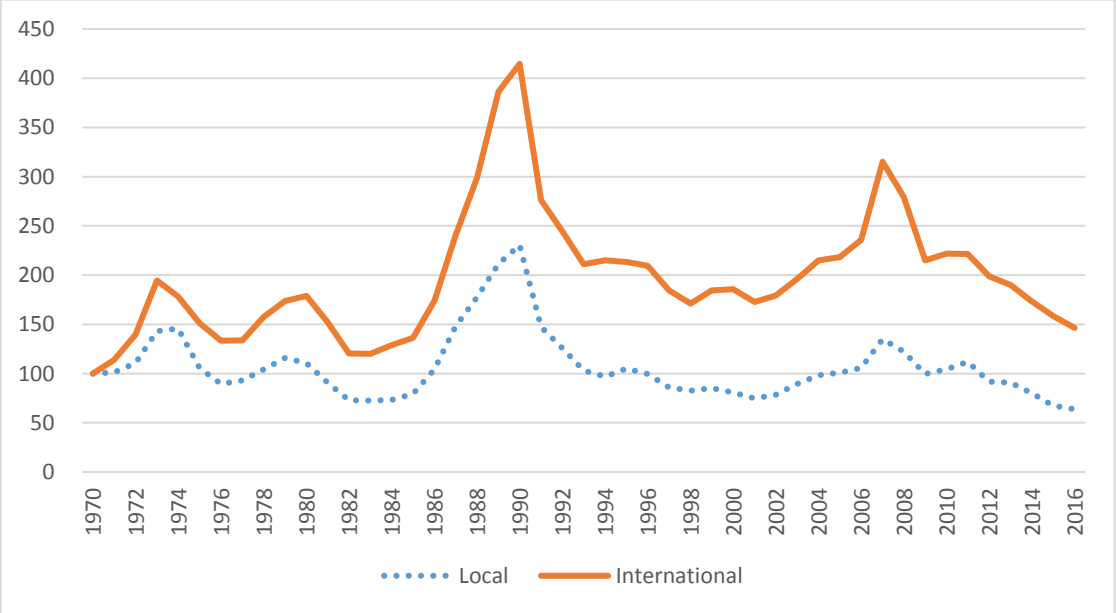


Figure 15 Price Indices of Local and International Markets since 1970 (Sotheby's & Christie's London and New York Branches as International, Indices Initial Values = 100)

This figure presents the art price indices of local and international markets (Sotheby's & Christie's London and New York branches as International) since 1970 detailed in Online Appendix 18. The observations are defined as International when the observations were sold at Sotheby's London, Sotheby's New York, Christie's London or Christie's New York and the observations are defined as Local otherwise. The initial indices values are set to be 100 in year 1970.

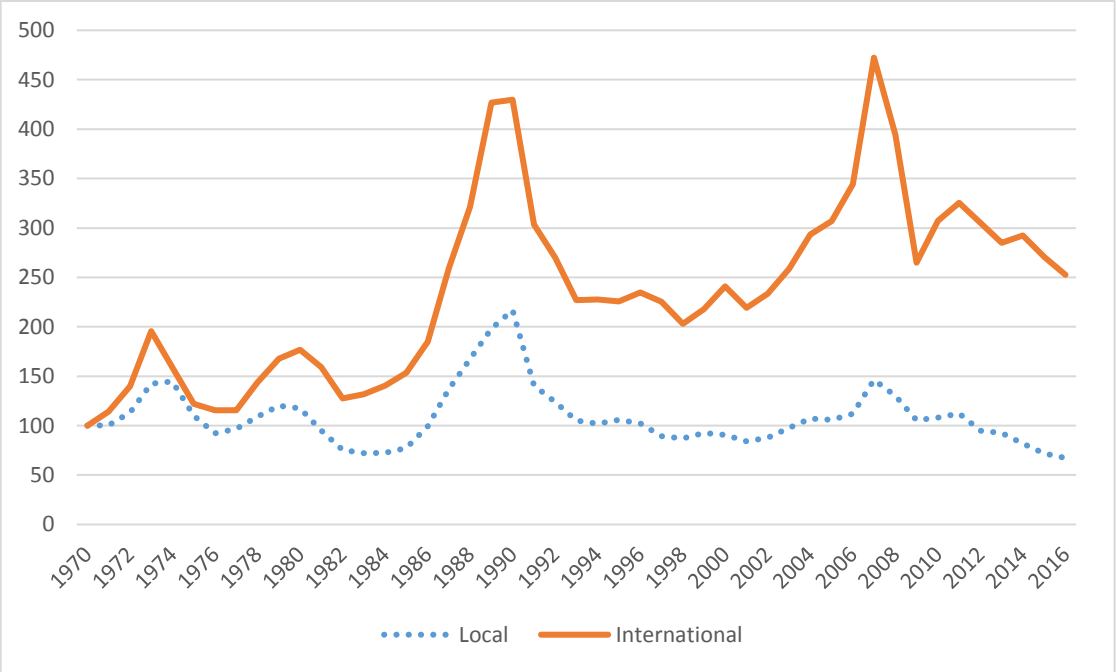


Figure 16 Price Indices of Artist Career Cycle since 1957 (Indices Initial Values = 100)

This figure presents the art price indices of artist career cycle since 1957 detailed in Appendix V. The observations are classified into three subsamples by the relative age when the artist created the paintings: (1) Young; (2) Middle; and (3) Old. The initial indices values are set to be 100 in year 1957.

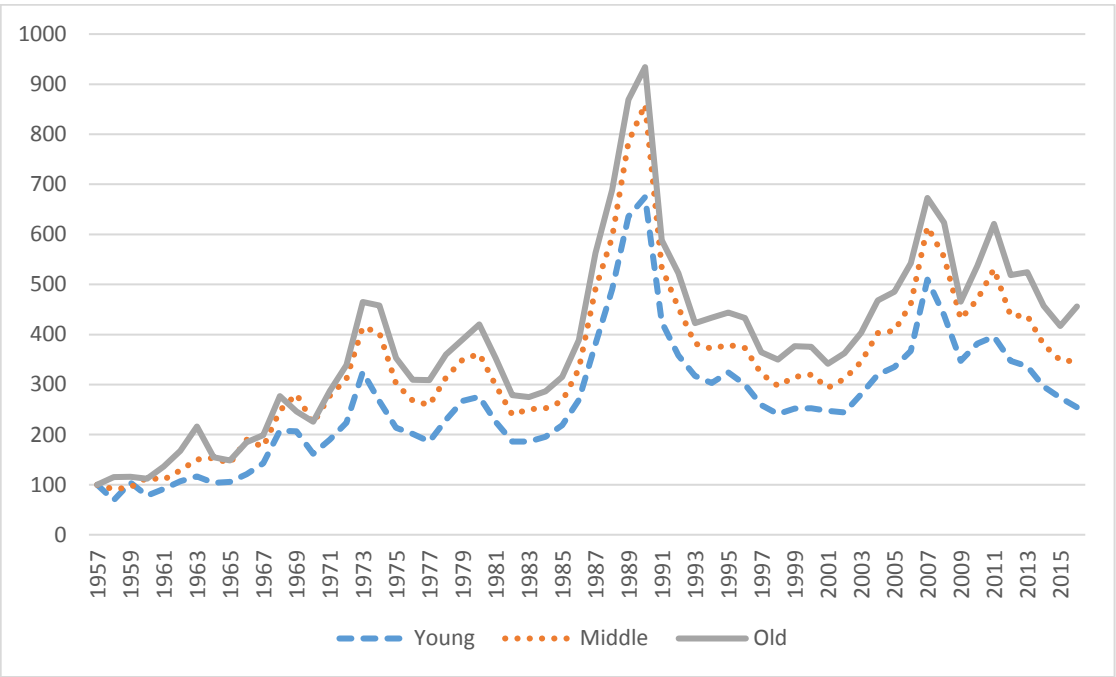
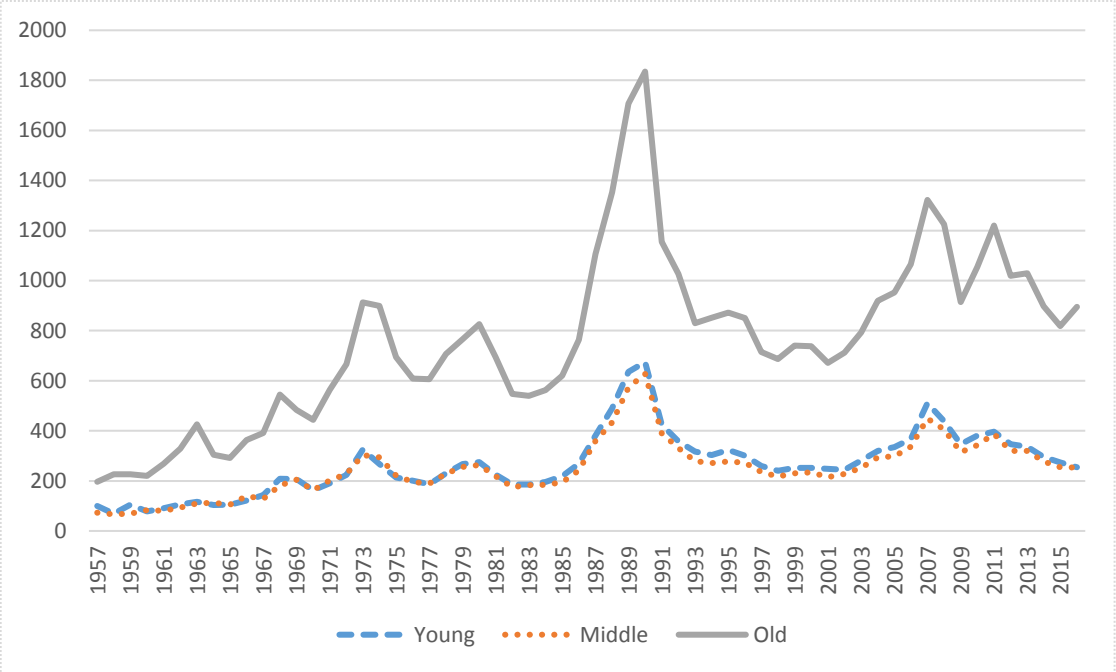


Figure 17 Price Indices of Artist Career Cycle since 1957 (Relative Indices Initial Values)

This figure presents the art price indices of artist career cycle since 1957 detailed in Appendix V. The observations are classified into three subsamples by the relative age when the artist created the paintings: (1) Young; (2) Middle; and (3) Old. The initial index value for young-age group is set to be 100 in 1957 and the initial indices values for other age groups are normalized by the average price from 1957 to 1961 relative to young-age group's.



Appendix
Appendix I Variable Definitions

Variable	Definition
Ln(Price)	Ln(Price) is the natural logarithm of deflated hammer price in US Dollars.
Height	The height of a painting measured in centimeters.
Width	The width of a painting measured in centimeters.
Oil	Oil refers to the Oil/Acryl Painting category based on the medium of a painting.
Watercolor	Watercolor refers to the Watercolor (or gouache) category based on the medium of a painting.
Drawing	Drawing refers to the Colored Drawing category based on the medium of a painting.
Signed	Signed is a dummy variable that equals one if the artwork bears physically identifiable signature(s) in various forms: full names, monograms, initials, countersignatures, and stamps.
Dated	Dated is a dummy variable that equals one if the artwork bears physically identifiable date(s).
Inscribed	Inscribed is a dummy variable that equals one if the artwork bears physically identifiable inscription(s).
Attributed	Attributed is a dummy variable equaling one if the auctioned object had been recognized and disclosed by the auction house at any of the following levels: 1) attributed to the artist, 2) from the studio of the artist, 3) from the circle of the artist, 4) from the school of the artist, 5) after the artist, or 6) in the style or manner of the artist.
Literature	Literature is a dummy variable equaling one if there is textual information in the catalogue about literature covering the auctioned lot.
Exhibited	Exhibited is a dummy variable equaling one if there is textual information in the catalogue about the exhibition history of the auctioned lot.
Provenance	Provenance is a dummy variable equaling one if there is textual information in the catalogue about the provenance information (past ownership, previous sales information, etc.) of the auctioned lot.
Authentication	Authentication is a dummy variable equaling one if there is textual information in the catalogue about the associated authentication either in the form of physical certificate or oral confirmation.
Deceased	Deceased is a dummy variable equaling one if the artist is dead before the sale of the auctioned lot.
Sotheby's London	Sotheby's London is a dummy variable that equals one if the sale takes place at Sotheby's London.
Sotheby's New York	Sotheby's New York is a dummy variable that equals one if the sale takes place at Sotheby's New York.
Sotheby's Other Branches	Sotheby's Other Branches is a dummy variable that equals one if the sale takes place at one of Sotheby's Other Branches.
Christie's London	Christie's London is a dummy variable that equals one if the sale takes place at Christie's London.
Christie's New York	Christie's New York is a dummy variable that equals one if the sale takes place at Christie's New York.
Christie's Other Branches	Christie's Other Branches is a dummy variable that equals one if the sale takes place at one of Christie's Other Branches.
Bonhams London	Bonhams London is a dummy variable that equals one if the sale takes place at Bonhams London.
Bonhams New York	Bonhams New York is a dummy variable that equals one if the sale takes place at Bonhams New York.
Bonhams Other Branches	Bonhams Other Branches is a dummy variable that equals one if the sale takes place at one of Bonhams Other Branches.
Phillips London	Phillips London is a dummy variable that equals one if the sale takes place at Phillips London.
Phillips New York	Phillips New York is a dummy variable that equals one if the sale takes place at Phillips New York.
Auction_American	Auction_American is a dummy variable that equals one if the sale takes place at one of the following important American auction houses: Butterfields (until 2002), Swann Auction Galleries, Skinner, Doyle New York, Freeman's, Leslie Hindman.
Auction_European	Auction_European is a dummy variable that equals one if the sale takes place at one of the following important American auction houses: Lyon & Turnbull (Scotland), Francis Briest / Artcurial Briest (France), Ader, Picard & Tajan / Ader & Tajan / Tajan (France), Bruun Rasmussen (Denmark), Dorotheum (Austria), Koller (Switzerland), Lempertz (Germany), Neumeister (Germany), Finarte (Italy), Bukowskis (Sweden), Stockholms Auktionsverk (Sweden).

Appendix II Hedonic Regressions by Art Media

This table presents the hedonic regression results of Oil paintings, Watercolors, and Drawings. Eq. (1) is estimated using OLS. The dependent variable is the natural log of deflated hammer price. Column (1), (2), (3) reports the regression results in subsamples of Oil painting, Watercolors, and Drawings, respectively. Standard errors are clustered at auction branch level and reported in parentheses. Column (4), (5), (6) reports the price impacts of corresponding variables in subsamples of Oil painting, Watercolors, and Drawings, respectively. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	Regression Results			Price Impacts		
Variables	Oil Painting	Watercolor	Drawing	Oil Painting	Watercolor	Drawing
Artist Characteristics						
Artist Characteristics						
Artist Fixed Effects	YES	YES	YES			
Deceased	0.1751***	0.1720***	0.1645***	19.14%	18.77%	17.88%
	(0.0257)	(0.0227)	(0.0252)			
Artwork Characteristics						
Attribution						
Attributed	-0.7529***	-0.9280***	-0.7669***	-52.90%	-60.47%	-53.55%
	(0.0301)	(0.0635)	(0.0347)			
Studio	-0.6745***	-0.6568***	-1.2188***	-49.06%	-48.15%	-70.44%
	(0.0559)	(0.1373)	(0.1012)			
Circle	-0.9739***	-0.7319***	-1.1469***	-62.24%	-51.90%	-68.24%
	(0.0561)	(0.0803)	(0.0987)			
School	-1.3003***	-0.9336***	-1.4715***	-72.75%	-60.69%	-77.04%
	(0.1004)	(0.1442)	(0.1091)			
After	-1.6883***	-1.1489***	-1.4795***	-81.52%	-68.30%	-77.22%
	(0.0689)	(0.1345)	(0.1620)			
Style	-1.5146***	-0.9858***	-1.4921***	-78.01%	-62.69%	-77.51%
	(0.0629)	(0.1042)	(0.1254)			
Authenticity						
Signed	0.1739***	0.1315***	0.1338***	18.99%	14.05%	14.32%
	(0.0136)	(0.0360)	(0.0279)			
Dated	0.1592***	0.1626***	0.1826***	17.26%	17.66%	20.03%
	(0.0053)	(0.0198)	(0.0156)			
Inscribed	0.0024	-0.0165	-0.0345**	0.24%	-1.64%	-3.39%
	(0.0092)	(0.0146)	(0.0164)			
Size						
Height	0.0061***	0.0070***	0.0057***	0.61%	0.70%	0.57%
	(0.0002)	(0.0004)	(0.0005)			
Width	0.0053***	0.0064***	0.0095***	0.53%	0.64%	0.95%
	(0.0002)	(0.0005)	(0.0009)			
Height_Sqr	-0.0001***	-0.0001***	-0.0001***	-0.01%	-0.01%	-0.01%
	(0.0000)	(0.0000)	(0.0000)			
Width_Sqr	-0.0001***	-0.0001***	-0.0001***	-0.01%	-0.01%	-0.01%
	(0.0000)	(0.0000)	(0.0000)			
Topic						
Abstract	-0.0333**	0.0449	0.0351	-3.28%	4.59%	3.57%
	(0.0137)	(0.0481)	(0.0297)			
Animals	-0.0427***	0.0621	0.0195	-4.18%	6.41%	1.97%
	(0.0097)	(0.0525)	(0.0369)			
Landscape	-0.0166**	0.0931	0.1126*	-1.65%	9.76%	11.92%
	(0.0071)	(0.0865)	(0.0581)			
Seascape	0.0584***	0.1209**	0.0990***	6.01%	12.85%	10.41%
	(0.0089)	(0.0517)	(0.0296)			
Urbanscape	0.1141***	0.1656***	0.1325***	12.09%	18.01%	14.17%

Appendix

	(1)	(2)	(3)	(4)	(5)	(6)
	Regression Results			Price Impacts		
Variables	Oil Painting	Watercolor	Drawing	Oil Painting	Watercolor	Drawing
	(0.0058)	(0.0496)	(0.0277)			
Nude	-0.0307***	0.0261	-0.0424	-3.02%	2.64%	-4.15%
	(0.0106)	(0.0559)	(0.0324)			
People	0.0152**	0.0899*	0.0460*	1.53%	9.41%	4.71%
	(0.0068)	(0.0491)	(0.0274)			
Self Portrait	0.0999***	0.3226***	0.3624***	10.51%	38.07%	43.68%
	(0.0264)	(0.0650)	(0.0444)			
Portrait	-0.2142***	-0.0386	0.0447*	-19.28%	-3.79%	4.57%
	(0.0121)	(0.0435)	(0.0243)			
Religion	-0.0041	0.0972*	0.0481	-0.41%	10.21%	4.93%
	(0.0140)	(0.0508)	(0.0301)			
Still Life	0.0384***	0.1147*	0.2018***	3.91%	12.15%	22.36%
	(0.0080)	(0.0662)	(0.0387)			
Study	-0.1847***	-0.0928**	-0.0999***	-16.86%	-8.86%	-9.51%
	(0.0114)	(0.0445)	(0.0217)			
Other Topic	0.0743***	0.1513**	0.1172***	7.71%	16.33%	12.43%
	(0.0091)	(0.0717)	(0.0409)			
Provenance Characteristics						
Provenance						
Pedigree	0.2898***	0.2962***	0.3413***	33.62%	34.47%	40.68%
	(0.0174)	(0.0203)	(0.0214)			
Exhibition	0.3774***	0.3468***	0.4000***	45.85%	41.45%	49.18%
	(0.0136)	(0.0150)	(0.0208)			
Literature	0.3668***	0.4131***	0.4466***	44.31%	51.15%	56.30%
	(0.0131)	(0.0198)	(0.0181)			
Authentication	0.1311***	0.2124***	0.0675	14.01%	23.66%	6.98%
	(0.0269)	(0.0323)	(0.0470)			
Transaction Characteristics						
Auction House						
Sotheby's London	0.6134***	0.5955***	0.5724***	84.67%	81.39%	77.25%
	(0.0256)	(0.0277)	(0.0276)			
Sotheby's New York	0.6188***	0.5798***	0.6306***	85.67%	78.57%	87.87%
	(0.0343)	(0.0391)	(0.0399)			
Sotheby's Other Branches	0.3312***	0.3696***	0.2954***	39.26%	44.72%	34.37%
	(0.0408)	(0.0490)	(0.0478)			
Christie's London	0.5830***	0.6364***	0.6070***	79.14%	88.97%	83.49%
	(0.0279)	(0.0292)	(0.0281)			
Christie's New York	0.4797***	0.4601***	0.4752***	61.56%	58.42%	60.83%
	(0.0270)	(0.0364)	(0.0391)			
Christie's Other Branches	0.1991***	0.1937***	0.1894**	22.03%	21.37%	20.85%
	(0.0570)	(0.0533)	(0.0735)			
Bonhams London	0.2477***	0.4351***	0.3753***	28.11%	54.51%	45.54%
	(0.0289)	(0.0318)	(0.0273)			
Bonhams Other Branches	-0.0046	-0.0677	-0.0374	-0.46%	-6.55%	-3.67%
	(0.0616)	(0.0883)	(0.0963)			
Phillips London	0.2152***	0.2236***	0.2205***	24.01%	25.06%	24.67%
	(0.0241)	(0.0276)	(0.0282)			
Phillips New York	0.3154***	0.2910***	0.3323***	37.08%	33.78%	39.42%
	(0.0277)	(0.0347)	(0.0348)			
Auction_American	-0.1020***	-0.1374***	-0.1895***	-9.70%	-12.84%	-17.26%
	(0.0305)	(0.0393)	(0.0527)			
Auction_European	0.1966***	0.0923***	0.0621**	21.73%	9.67%	6.41%
	(0.0377)	(0.0319)	(0.0271)			
Month						
Month Fixed Effects	YES	YES	YES			

Appendix

	(1)	(2)	(3)	(4)	(5)	(6)
		Regression Results			Price Impacts	
Variables	Oil Painting	Watercolor	Drawing	Oil Painting	Watercolor	Drawing
Year						
Year Fixed Effects	YES	YES	YES			
Constant	6.0067***	5.9735***	6.7099***			
	(0.0941)	(0.1172)	(0.1278)			
Observations	1,387,027	405,937	352,642			
R-squared	0.7688	0.7308	0.6575			

Appendix III Hedonic Regression by Art Movements (5 Groups)

This table presents the hedonic regression results of movements since 1957. Eq. (1) is estimated using OLS. The dependent variable is the natural log of deflated hammer price. We run regressions on five groups of movements: (1) Medieval & Renaissance, Baroque, Rococo; (2) Neoclassicism, Romanticism, Realism; and (3) Impressionism & Symbolism; (4) Fauvism & Expressionism, Cubism, Futurism & Constructivism, Dada & Surrealism; (5) Abstract Expressionism, Pop, Minimalism & Contemporary. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors are clustered at auction branch level and reported in parentheses.

Variables	(1) Medieval and Renaissance/Baroque/Rococo	(2) Neoclassicism/Romanticism/Realism	(3) Impressionism and Symbolism	(4) FE/CFC/DS	(5) Abstract Expressionism/Pop/Minimalism and Contemporary
Artist Characteristics					
Artist Characteristics					
Artist Fixed Effects	YES	YES	YES	YES	YES
Deceased		-0.054**	-0.605	0.068***	0.087
		(0.025)	(0.439)	(0.012)	(0.000)
Artwork Characteristics					
Attribution					
Attributed	-0.722***	-0.994***	-1.333***	-1.556***	-1.919
	(0.007)	(0.013)	(0.032)	(0.054)	(0.000)
Studio	-0.693***	-1.041***	-1.407***	-1.377***	-1.348
	(0.013)	(0.042)	(0.312)	(0.244)	(0.000)
Circle	-0.983***	-1.405***	-1.831***	-2.188***	
	(0.008)	(0.026)	(0.179)	(0.314)	
School	-1.257***	-1.769***	-2.455***	-2.508***	
	(0.013)	(0.040)	(0.181)	(0.408)	
After	-1.739***	-2.128***	-2.320***	-2.352***	-1.313
	(0.013)	(0.035)	(0.179)	(0.188)	(0.000)
Style	-1.536***	-1.984***	-2.514***	-1.775***	-0.843
	(0.008)	(0.025)	(0.117)	(0.340)	(0.000)
Authenticity					
Signed	0.240***	0.241***	0.321***	0.269***	0.088
	(0.009)	(0.008)	(0.008)	(0.006)	(0.000)

Appendix

Variables	(1) Medieval and Renaissance/Baroque/Rococo	(2) Neoclassicism/Romanticism/Realism	(3) Impressionism and Symbolism	(4) FE/CFC/DS	(5) Abstract Expressionism/Pop/Minimalism and Contemporary
Dated	0.261***	0.257***	0.193***	0.137***	0.173
	(0.010)	(0.008)	(0.008)	(0.006)	(0.000)
Inscribed	0.026***	0.007	-0.013	-0.051***	-0.014
	(0.009)	(0.009)	(0.010)	(0.007)	(0.000)
Medium					
Oil	0.932***	1.213***	1.283***	1.497***	0.806
	(0.011)	(0.011)	(0.012)	(0.009)	(0.000)
Watercolor	0.188***	0.583***	0.531***	0.642***	0.239
	(0.020)	(0.011)	(0.011)	(0.006)	(0.000)
Size					
Height	0.003***	0.010***	0.019***	0.013***	0.008
	(0.000)	(0.001)	(0.002)	(0.001)	(0.000)
Width	0.006***	0.009***	0.016***	0.008***	0.005
	(0.000)	(0.001)	(0.001)	(0.001)	(0.000)
Height_Sqr	-0.000***	-0.000***	-0.000***	-0.000***	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Width_Sqr	-0.000***	-0.000**	-0.000***	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Topic					
Abstract	0.129	-0.218***	-0.184	0.011	0.032
	(0.120)	(0.055)	(0.112)	(0.012)	(0.000)
Animals	-0.083***	-0.056***	-0.101***	-0.070***	0.000
	(0.012)	(0.015)	(0.018)	(0.012)	(0.000)
Landscape	-0.029***	-0.002	0.008	-0.007	0.065
	(0.010)	(0.011)	(0.012)	(0.010)	(0.000)
Seascape	-0.074***	0.042***	0.159***	0.160***	0.160
	(0.018)	(0.015)	(0.014)	(0.014)	(0.000)
Urbanscape	0.050***	0.107***	0.120***	0.095***	0.089
	(0.012)	(0.013)	(0.013)	(0.011)	(0.000)
Nude	-0.030	-0.275***	-0.154***	-0.077***	-0.040
	(0.034)	(0.018)	(0.020)	(0.012)	(0.000)

Appendix

Variables	(1) Medieval and Renaissance/Baroque/Rococo	(2) Neoclassicism/Romanticism/Realism	(3) Impressionism and Symbolism	(4) FE/CFC/DS	(5) Abstract Expressionism/Pop/Minimalism and Contemporary
People	-0.036***	-0.035***	0.033***	0.061***	0.089
	(0.007)	(0.011)	(0.012)	(0.009)	(0.000)
Self Portrait	0.268***	0.228***	0.200***	0.262***	0.529
	(0.079)	(0.044)	(0.048)	(0.031)	(0.000)
Portrait	-0.133***	-0.183***	-0.234***	-0.112***	-0.001
	(0.012)	(0.015)	(0.017)	(0.013)	(0.000)
Religion	-0.101***	-0.122***	0.042**	0.021	0.015
	(0.010)	(0.023)	(0.021)	(0.019)	(0.000)
Still Life	0.126***	0.217***	0.064***	0.079***	0.132
	(0.016)	(0.019)	(0.017)	(0.010)	(0.000)
Study	-0.059***	-0.199***	-0.318***	-0.134***	0.053
	(0.019)	(0.017)	(0.018)	(0.016)	(0.000)
Other Topic	-0.057***	0.091***	0.092***	0.069***	0.132
	(0.010)	(0.012)	(0.012)	(0.009)	(0.000)
Provenance Characteristics					
Provenance					
Pedigree	0.252***	0.346***	0.319***	0.325***	0.376
	(0.010)	(0.011)	(0.011)	(0.008)	(0.000)
Exhibition	0.512***	0.428***	0.475***	0.385***	0.342
	(0.018)	(0.015)	(0.014)	(0.010)	(0.000)
Literature	0.506***	0.470***	0.275***	0.398***	0.479
	(0.014)	(0.015)	(0.013)	(0.010)	(0.000)
Authentication	0.130***	0.193***	0.181***	0.107***	0.095
	(0.042)	(0.036)	(0.032)	(0.016)	(0.000)
Transaction Characteristics					
Auction House					
Sotheby's London	0.529***	0.751***	0.680***	0.601***	0.732
	(0.009)	(0.012)	(0.012)	(0.009)	(0.000)
Sotheby's New York	0.540***	0.773***	0.657***	0.564***	0.496

Appendix

Variables	(1) Medieval and Renaissance/Baroque/Rococo	(2) Neoclassicism/Romanticism/Realism	(3) Impressionism and Symbolism	(4) FE/CFC/DS	(5) Abstract Expressionism/Pop/Minimalism and Contemporary
	(0.011)	(0.011)	(0.012)	(0.009)	(0.000)
Sotheby's Other Branches	0.341***	0.305***	0.250***	0.264***	0.132
	(0.010)	(0.017)	(0.019)	(0.014)	(0.000)
Christie's London	0.515***	0.713***	0.616***	0.615***	0.676
	(0.009)	(0.013)	(0.014)	(0.010)	(0.000)
Christie's New York	0.384***	0.645***	0.571***	0.448***	0.374
	(0.013)	(0.013)	(0.015)	(0.011)	(0.000)
Christie's Other Branches	0.106***	0.250***	0.243***	0.116***	0.128
	(0.008)	(0.013)	(0.015)	(0.011)	(0.000)
Bonhams London	-0.209***	0.177***	0.193***	0.207***	0.301
	(0.021)	(0.035)	(0.053)	(0.050)	(0.000)
Bonhams Other Branches	-0.055*	0.112***	0.069*	-0.050	-0.193
	(0.031)	(0.029)	(0.041)	(0.036)	(0.000)
Phillips London	0.014	0.225***	0.171***	0.135***	0.392
	(0.014)	(0.029)	(0.046)	(0.038)	(0.000)
Phillips New York	-0.131**	0.388***	0.300***	0.336***	0.276
	(0.059)	(0.047)	(0.052)	(0.054)	(0.000)
Auction_American	-0.289***	-0.035**	-0.032*	-0.224***	-0.302
	(0.018)	(0.015)	(0.018)	(0.022)	(0.000)
Auction_European	0.277***	0.192***	0.110***	0.074***	0.033
	(0.008)	(0.010)	(0.010)	(0.007)	(0.000)
Month					
Month Fixed Effects	YES	YES	YES	YES	YES
Year					
Year Fixed Effects	YES	YES	YES	YES	YES
Constant	7.002***	5.648***	5.637***	5.582***	5.474
	(0.057)	(0.103)	(0.433)	(0.132)	(0.000)
Observations	202,851	135,080	117,075	193,009	106,233
R-squared	0.548	0.639	0.736	0.732	0.711

Appendix IV Hedonic Regressions by Artist Life Cycle since 1957

This table presents the hedonic regression results by artist life cycle since 1957. The observations are classified into three subsamples by the age when the artist created the paintings: (I) below (equal to) 30; (II) above 30 and below (equal to) 50; and (III) above 50. Column (1), (2), (3) reports the regression results in subsamples of (I) below (equal to) 30; (II) above 30 and below (equal to) 50; and (III) above 50, respectively. Standard errors are clustered at auction branch level and reported in parentheses. Column (4), (5), (6) reports the price impacts of corresponding variables in subsamples of (I) below (equal to) 30; (II) above 30 and below (equal to) 50; and (III) above 50, respectively. The dependent variable is the natural log of deflated hammer price. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	Regression Results			Price Impacts		
Variables	Under 30	30 to 50	Above 50	Under 30	30 to 50	Above 50
Artist Characteristics						
Artist Characteristics						
Artist Fixed Effects	YES	YES	YES			
Deceased	0.1738***	0.1847***	0.0981***	18.98%	20.29%	10.31%
	(0.0382)	(0.0282)	(0.0259)			
Artwork Characteristics						
Attribution						
Attributed	-0.9348***	-1.2204***	-1.3358***	-60.73%	-70.49%	-73.71%
	(0.0564)	(0.0563)	(0.0865)			
Studio	0.1423	-1.0425***	-0.7284***	15.29%	-64.74%	-51.73%
	(0.3586)	(0.1570)	(0.1738)			
Circle	-1.1774***	-1.2053***	-1.3636***	-69.19%	-70.04%	-74.43%
	(0.2029)	(0.1173)	(0.1316)			
School	-1.6530***	-1.3142***	-1.5440***	-80.85%	-73.13%	-78.65%
	(0.5440)	(0.2416)	(0.1335)			
After	-1.5140***	-1.4731***	-1.4282***	-78.00%	-77.08%	-76.03%
	(0.3697)	(0.1916)	(0.1745)			
Style	-1.4080***	-1.7615***	-1.6291***	-75.54%	-82.82%	-80.39%
	(0.1626)	(0.1409)	(0.1103)			
Authenticity						
Signed	0.2089***	0.1904***	0.1659***	23.23%	20.97%	18.05%
	(0.0182)	(0.0260)	(0.0394)			
Dated	-0.0011	0.0397***	0.0215	-0.11%	4.05%	2.17%
	(0.0173)	(0.0125)	(0.0169)			
Inscribed	-0.0121	-0.0308***	-0.0676***	-1.20%	-3.03%	-6.54%
	(0.0101)	(0.0105)	(0.0132)			
Medium						
Oil	1.1315***	1.1740***	1.2382***	210.03%	223.49%	244.94%
	(0.0212)	(0.0203)	(0.0223)			
Watercolor	0.4411***	0.4007***	0.4904***	55.44%	49.29%	63.30%
	(0.0243)	(0.0197)	(0.0275)			
Size						
Height	0.0107***	0.0080***	0.0077***	1.08%	0.80%	0.77%
	(0.0007)	(0.0002)	(0.0003)			
Width	0.0072***	0.0047***	0.0071***	0.72%	0.47%	0.71%
	(0.0009)	(0.0002)	(0.0002)			
Height_Sqr	-0.0001***	-0.0001***	-0.0001***	-0.01%	-0.01%	-0.01%
	(0.0000)	(0.0000)	(0.0000)			
Width_Sqr	-0.0001*	0.0001**	-0.0001***	-0.01%	0.01%	-0.01%
	(0.0000)	(0.0000)	(0.0000)			
Topic						
Abstract	0.0375	-0.0265	0.0099	3.82%	-2.62%	0.99%

Appendix

	(1)	(2)	(3)	(4)	(5)	(6)
	Regression Results			Price Impacts		
Variables	Under 30	30 to 50	Above 50	Under 30	30 to 50	Above 50
	(0.0300)	(0.0187)	(0.0215)			
Animals	-0.0503**	-0.0263*	0.0189	-4.91%	-2.60%	1.91%
	(0.0248)	(0.0135)	(0.0199)			
Landscape	-0.0102	0.0148	0.0902***	-1.01%	1.49%	9.44%
	(0.0160)	(0.0179)	(0.0294)			
Seascape	0.0780**	0.0903***	0.0982***	8.11%	9.45%	10.32%
	(0.0323)	(0.0135)	(0.0185)			
Urbanscape	0.0738***	0.1147***	0.1483***	7.66%	12.15%	15.99%
	(0.0178)	(0.0122)	(0.0159)			
Nude	-0.2315***	-0.1059***	0.0266	-20.67%	-10.05%	2.70%
	(0.0326)	(0.0207)	(0.0268)			
People	-0.0278*	0.0108	0.0565***	-2.74%	1.09%	5.81%
	(0.0157)	(0.0137)	(0.0196)			
Self Portrait	0.2179***	0.1754***	0.2006***	24.35%	19.17%	22.21%
	(0.0411)	(0.0349)	(0.0392)			
Portrait	-0.1914***	-0.1990***	-0.2172***	-17.42%	-18.05%	-19.52%
	(0.0256)	(0.0196)	(0.0227)			
Religion	0.0298	0.0370*	0.0482*	3.02%	3.77%	4.94%
	(0.0393)	(0.0212)	(0.0251)			
Still Life	0.0770**	0.1301***	0.1757***	8.00%	13.89%	19.21%
	(0.0313)	(0.0169)	(0.0224)			
Study	-0.1580***	-0.1839***	-0.1652***	-14.62%	-16.80%	-15.23%
	(0.0432)	(0.0200)	(0.0266)			
Other Topic	0.0679***	0.0912***	0.1181***	7.03%	9.55%	12.54%
	(0.0130)	(0.0154)	(0.0234)			
Provenance Characteristics						
Provenance						
Pedigree	0.2895***	0.2526***	0.2601***	33.58%	28.74%	29.71%
	(0.0146)	(0.0159)	(0.0167)			
Exhibition	0.3629***	0.3117***	0.2823***	43.75%	36.57%	32.62%
	(0.0234)	(0.0116)	(0.0121)			
Literature	0.3782***	0.3503***	0.2977***	45.97%	41.95%	34.68%
	(0.0207)	(0.0166)	(0.0159)			
Authentication	0.2061***	0.1431***	0.0878*	22.89%	15.38%	9.18%
	(0.0671)	(0.0404)	(0.0456)			
Transaction Characteristics						
Auction House						
Sotheby's London	0.5991***	0.5170***	0.4349***	82.05%	67.70%	54.48%
	(0.0260)	(0.0263)	(0.0258)			
Sotheby's New York	0.5294***	0.4725***	0.4108***	69.79%	60.40%	50.80%
	(0.0404)	(0.0369)	(0.0366)			
Sotheby's Other Branches	0.2663***	0.2386***	0.1544***	30.51%	26.95%	16.70%
	(0.0450)	(0.0357)	(0.0414)			
Christie's London	0.6203***	0.5370***	0.4529***	85.95%	71.09%	57.29%
	(0.0255)	(0.0267)	(0.0257)			
Christie's New York	0.4496***	0.3912***	0.3557***	56.77%	47.88%	42.72%
	(0.0379)	(0.0345)	(0.0347)			
Christie's Other Branches	0.1760**	0.1417*	0.0534	19.24%	15.22%	5.49%
	(0.0809)	(0.0792)	(0.0708)			
Bonhams London	0.3606***	0.3114***	0.2606***	43.42%	36.53%	29.77%
	(0.0314)	(0.0384)	(0.0311)			
Bonhams Other Branches	-0.0783	-0.0943	-0.1749	-7.53%	-9.00%	-16.05%
	(0.1118)	(0.1139)	(0.1170)			
Phillips London	0.3311***	0.1871***	0.1932***	39.25%	20.57%	21.31%
	(0.0274)	(0.0283)	(0.0243)			

Appendix

	(1)	(2)	(3)	(4)	(5)	(6)
	Regression Results			Price Impacts		
Variables	Under 30	30 to 50	Above 50	Under 30	30 to 50	Above 50
Phillips New York	0.4278***	0.2755***	0.2692***	53.39%	31.72%	30.89%
	(0.0443)	(0.0285)	(0.0360)			
Auction_American	-0.1777***	-0.1960***	-0.1867***	-16.28%	-17.80%	-17.03%
	(0.0467)	(0.0395)	(0.0435)			
Auction_European	0.0568	0.0712***	0.0321	5.84%	7.38%	3.26%
	(0.0358)	(0.0270)	(0.0252)			
Month						
Month Fixed Effects	YES	YES	YES			
Year						
Year Fixed Effects	YES	YES	YES			
Constant	5.5508***	5.5025***	5.5820***			
	(0.1727)	(0.1425)	(0.2862)			
Observations	70,118	250,604	226,124			
R-squared	0.7528	0.7643	0.7804			

Appendix V Hedonic Regressions by Artist Career Cycle since 1957

This table presents the hedonic regression results by artist career cycle since 1957. The auctioned lots are classified into three subsamples by the relative age groups when artists created the paintings: (I) Young; (II) Middle; and (III) Old. The auctioned lots are defined as (I) Young-age works if the artists created the art works below 18 or in the first one-third career phase after 18; defined as (II) Middle-age works if the artists created the art works during the middle one-third career phase after 18; defined as (III) Old-age works if the artists created the art works during the last one-third career phase after 18. Column (1), (2), (3) reports the regression results in subsamples of (I) Young, (II) Middle. and (III) Old, respectively. Standard errors are clustered at auction branch level and reported in parentheses. Column (4), (5), (6) reports the price impacts of corresponding variables in subsamples of (I) Young, (II) Middle. and (III) Old, respectively. The dependent variable is the natural log of deflated hammer price. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
		Regression Results			Price Impacts	
Variables	Young	Middle	Old	Young	Middle	Old
Artist Characteristics						
Artist Characteristics						
Artist Fixed Effects	YES	YES	YES			
Deceased	0.1555***	0.1810***	0.0779**	16.82%	19.84%	8.10%
	(0.0274)	(0.0258)	(0.0331)			
Artwork Characteristics						
Attribution						
Attributed	-0.9808***	-1.2116***	-1.3781***	-62.50%	-70.23%	-74.79%
	(0.0506)	(0.0647)	(0.0849)			
Studio	-0.0006	-0.9801***	-0.8581***	-0.06%	-62.47%	-57.60%
	(0.3611)	(0.1678)	(0.1843)			
Circle	-1.2167***	-1.1677***	-1.4239***	-70.38%	-68.89%	-75.92%
	(0.1737)	(0.0912)	(0.1197)			
School	-1.4850***	-1.3349***	-1.5157***	-77.35%	-73.68%	-78.03%
	(0.4427)	(0.2142)	(0.1392)			
After	-1.3322***	-1.6739***	-1.4605***	-73.61%	-81.25%	-76.79%
	(0.2826)	(0.1959)	(0.1810)			
Style	-1.3660***	-1.7378***	-1.5768***	-74.49%	-82.41%	-79.34%
	(0.2377)	(0.1060)	(0.1094)			
Authenticity						
Signed	0.2035***	0.1942***	0.1503***	22.57%	21.43%	16.22%
	(0.0183)	(0.0263)	(0.0389)			
Dated	-0.0020	0.0423***	0.0261	-0.20%	4.32%	2.64%
	(0.0153)	(0.0148)	(0.0187)			
Inscribed	-0.0181*	-0.0444***	-0.0676***	-1.79%	-4.34%	-6.54%
	(0.0108)	(0.0114)	(0.0143)			
Medium						
Oil	1.1514***	1.1145***	1.2371***	216.26%	204.80%	244.56%
	(0.0184)	(0.0211)	(0.0244)			
Watercolor	0.4238***	0.4073***	0.4929***	52.78%	50.28%	63.71%
	(0.0163)	(0.0207)	(0.0301)			
Size						
Height	0.0093***	0.0058***	0.0089***	0.93%	0.58%	0.89%
	(0.0007)	(0.0002)	(0.0006)			
Width	0.0081***	0.0114***	0.0068***	0.81%	1.15%	0.68%
	(0.0007)	(0.0008)	(0.0004)			
Height_Sqr	-0.0001***	-0.0001***	-0.0001*	-0.01%	-0.01%	-0.01%
	(0.0000)	(0.0000)	(0.0000)			
Width_Sqr	-0.0001***	-0.0001***	-0.0001	-0.01%	-0.01%	-0.01%

Appendix

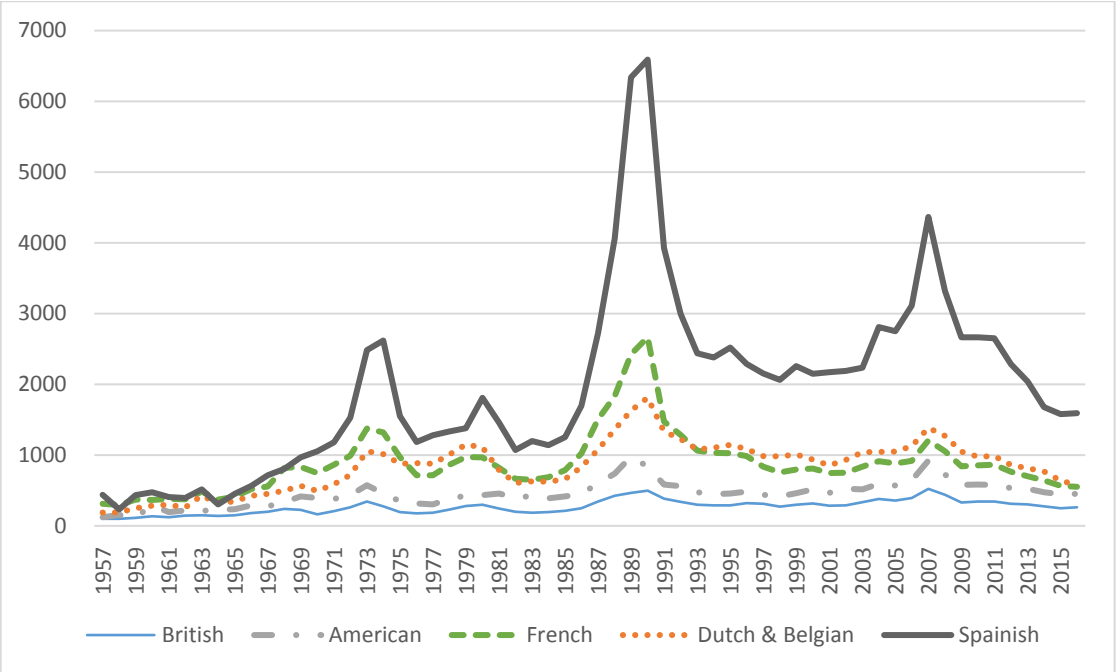
	(1)	(2)	(3)	(4)	(5)	(6)
	Regression Results			Price Impacts		
Variables	Young	Middle	Old	Young	Middle	Old
	(0.0000)	(0.0000)	(0.0000)			
Topic						
Abstract	0.0069	-0.0175	-0.0015	0.69%	-1.73%	-0.15%
	(0.0249)	(0.0165)	(0.0211)			
Animals	-0.0135	-0.0431***	0.0081	-1.34%	-4.22%	0.81%
	(0.0188)	(0.0154)	(0.0188)			
Landscape	-0.0109	0.0216	0.0750***	-1.08%	2.18%	7.79%
	(0.0177)	(0.0175)	(0.0261)			
Seascape	0.0659***	0.0720***	0.1000***	6.81%	7.47%	10.52%
	(0.0213)	(0.0147)	(0.0168)			
Urbanscape	0.0964***	0.1071***	0.1431***	10.12%	11.30%	15.38%
	(0.0142)	(0.0128)	(0.0155)			
Nude	-0.1915***	-0.0581***	-0.0030	-17.43%	-5.64%	-0.30%
	(0.0274)	(0.0213)	(0.0274)			
People	-0.0055	0.0368**	0.0398**	-0.55%	3.75%	4.06%
	(0.0140)	(0.0166)	(0.0160)			
Self Portrait	0.1876***	0.1571***	0.2542***	20.64%	17.01%	28.94%
	(0.0373)	(0.0412)	(0.0465)			
Portrait	-0.1901***	-0.2118***	-0.2134***	-17.31%	-19.09%	-19.22%
	(0.0213)	(0.0173)	(0.0229)			
Religion	0.0044	0.0491**	0.0338	0.44%	5.03%	3.44%
	(0.0365)	(0.0228)	(0.0255)			
Still Life	0.0987***	0.1283***	0.1708***	10.37%	13.69%	18.63%
	(0.0244)	(0.0137)	(0.0212)			
Study	-0.1598***	-0.1629***	-0.1709***	-14.77%	-15.03%	-15.71%
	(0.0325)	(0.0235)	(0.0267)			
Other Topic	0.0809***	0.0818***	0.1106***	8.43%	8.52%	11.69%
	(0.0136)	(0.0149)	(0.0194)			
Provenance Characteristics						
Provenance						
Pedigree	0.3008***	0.2634***	0.2712***	35.09%	30.13%	31.15%
	(0.0167)	(0.0157)	(0.0171)			
Exhibition	0.3725***	0.2923***	0.2703***	45.14%	33.95%	31.04%
	(0.0163)	(0.0102)	(0.0131)			
Literature	0.3624***	0.3526***	0.2778***	43.68%	42.28%	32.02%
	(0.0180)	(0.0141)	(0.0207)			
Authentication	0.1750***	0.1527***	0.0846*	19.12%	16.50%	8.83%
	(0.0460)	(0.0524)	(0.0461)			
Transaction Characteristics						
Auction House						
Sotheby's London	0.5402***	0.4705***	0.4568***	71.64%	60.08%	57.90%
	(0.0261)	(0.0271)	(0.0248)			
Sotheby's New York	0.5275***	0.4315***	0.4236***	69.47%	53.96%	52.75%
	(0.0416)	(0.0338)	(0.0389)			
Sotheby's Other Branches	0.2775***	0.2152***	0.1398***	31.98%	24.01%	15.00%
	(0.0403)	(0.0362)	(0.0426)			
Christie's London	0.5743***	0.4804***	0.4782***	77.59%	61.67%	61.32%
	(0.0258)	(0.0265)	(0.0246)			
Christie's New York	0.4375***	0.3672***	0.3719***	54.88%	44.37%	45.05%
	(0.0413)	(0.0324)	(0.0359)			
Christie's Other Branches	0.1658*	0.1171*	0.0562	18.03%	12.42%	5.78%
	(0.0879)	(0.0693)	(0.0787)			
Bonhams London	0.2025***	0.3223***	0.2978***	22.45%	38.03%	34.69%
	(0.0325)	(0.0402)	(0.0306)			
Bonhams Other Branches	-0.1079	-0.1012	-0.1597	-10.23%	-9.62%	-14.76%

Appendix

	(1)	(2)	(3)	(4)	(5)	(6)
	Regression Results			Price Impacts		
Variables	Young	Middle	Old	Young	Middle	Old
	(0.1367)	(0.1058)	(0.1302)			
Phillips London	0.1773***	0.2307***	0.1856***	19.40%	25.95%	20.39%
	(0.0266)	(0.0244)	(0.0232)			
Phillips New York	0.5557***	0.3096***	0.2165***	74.32%	36.29%	24.17%
	(0.0452)	(0.0305)	(0.0341)			
Auction_American	-0.2010***	-0.1634***	-0.2056***	-18.21%	-15.07%	-18.58%
	(0.0459)	(0.0380)	(0.0452)			
Auction_European	0.0734**	0.0615**	0.0331	7.62%	6.34%	3.37%
	(0.0300)	(0.0265)	(0.0250)			
Month						
Month Fixed Effects	YES	YES	YES			
Year						
Year Fixed Effects	YES	YES	YES			
Constant	5.5508***	5.5025***	5.5820***			
	(0.1727)	(0.1425)	(0.2862)			
Observations	70,118	250,604	226,124			
R-squared	0.7528	0.7643	0.7804			

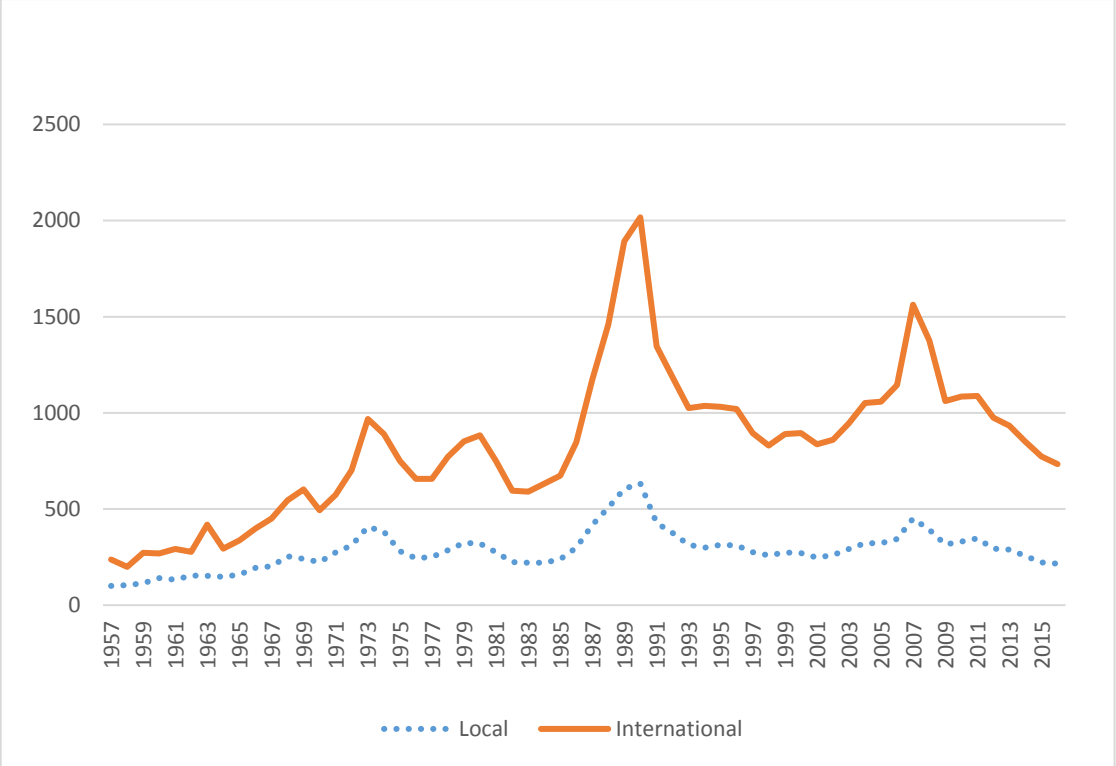
Appendix VI Price Indices of Artist Nationalities since 1957 (Relative Indices Initial Values)

This figure presents the art price indices of British, American; French, Dutch & Belgian, and Spanish artists since 1957 detailed in Online Appendix 10. The initial index value for British artists is set to be 100 in 1957 and the initial indices values are normalized by the average prices from 1957 to 1961 relative to British artists'.



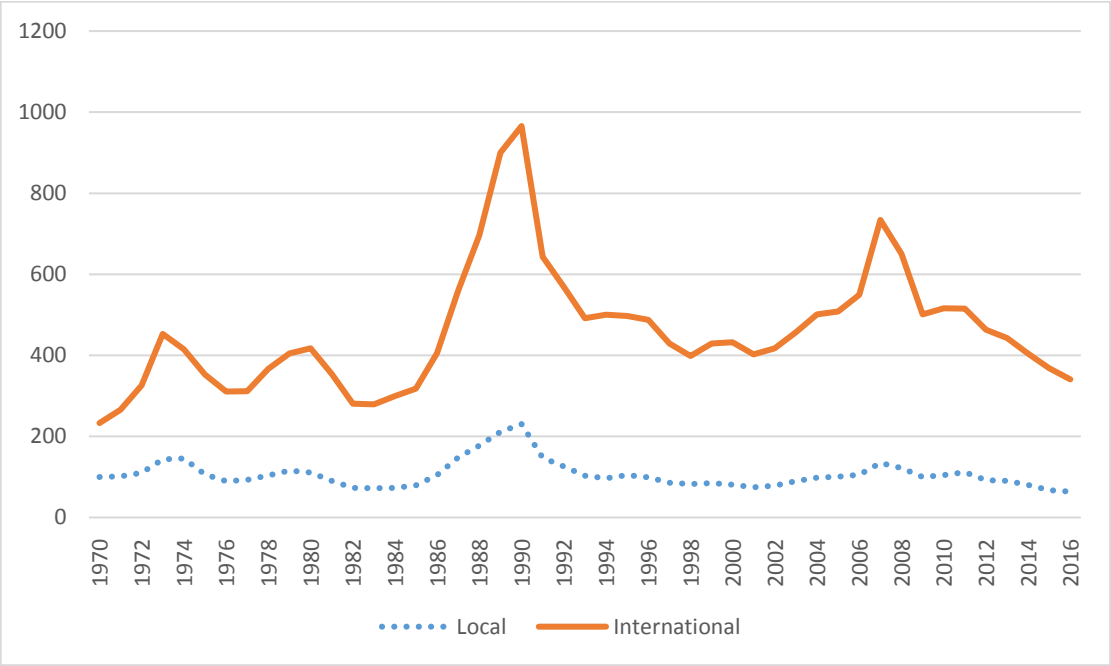
Appendix VII Price Indices of Local and International Markets since 1957 (Relative Indices Initial Values)

This figure presents the art price indices of local and international markets since 1957 detailed in Online Appendix 16. The observations are defined as Local when the artist nationality is the same as the sale country. The observations are defined as International when the artist nationality is different from the sale country. The initial index value for local markets is set to be 100 in 1957 and the initial index value for international markets is normalized by the average price from 1957 to 1961 relative to local markets'.



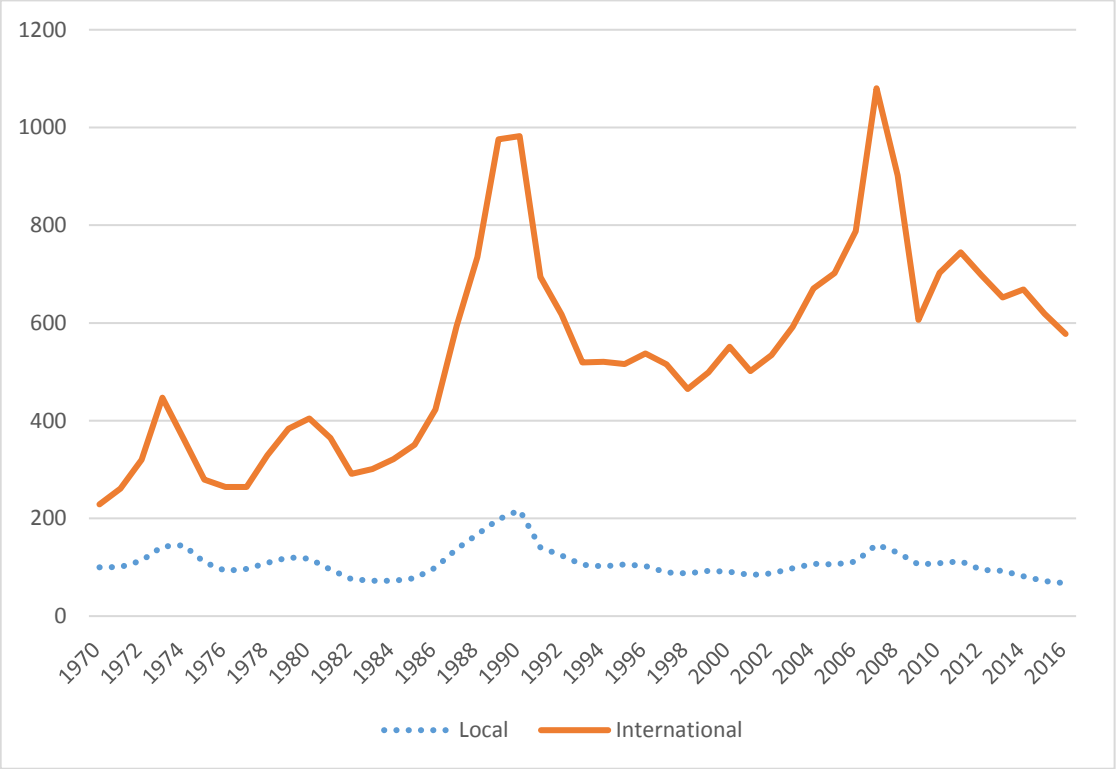
Appendix VIII Price Indices of Local and International Markets since 1970 (Excluding British and American Artists, Relative Indices Initial Values)

This figure presents the art price indices of local and international markets excluding British and American artists since 1970 detailed in Online Appendix 17. The observations are defined as Local when the artist nationality (excluding British and American artists) is the same as the sale country. The observations are defined as International when the artist nationality (excluding British and American artists) is different from the sale country. The initial index value for local markets is set to be 100 in 1970 and the initial index value for international markets is normalized by the average price from 1970 to 1974 relative to local markets'.



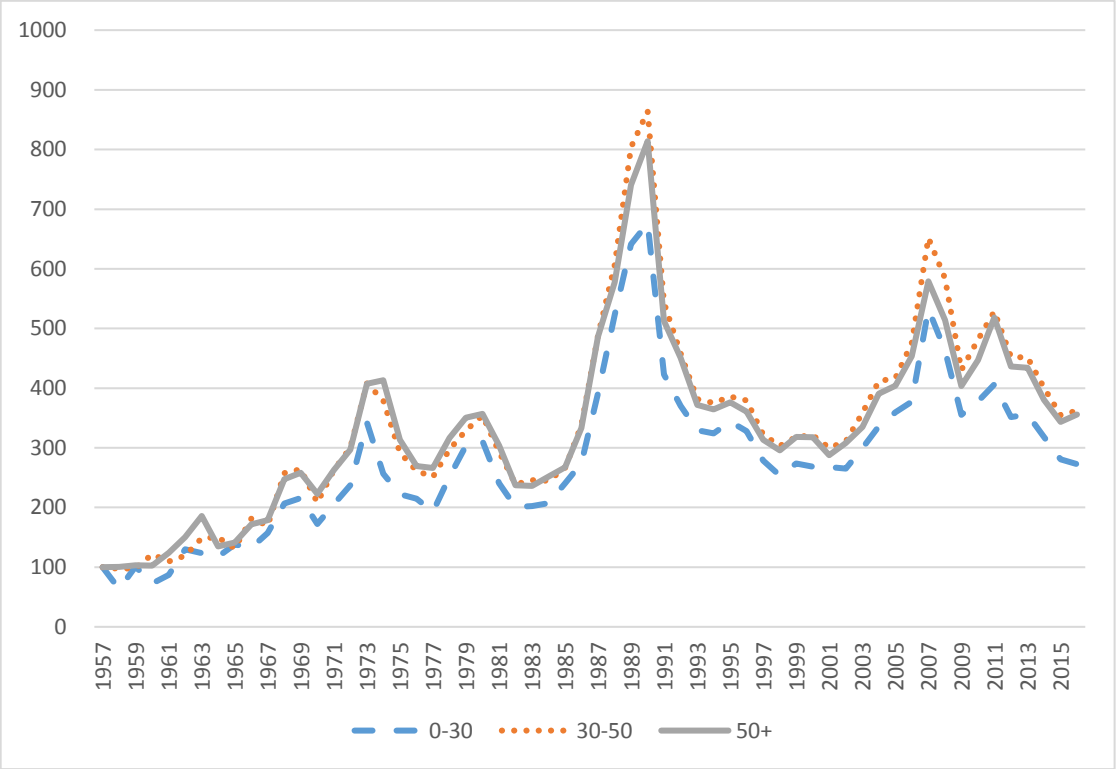
Appendix IX Price Indices of Local and International Markets since 1970 (Sotheby's & Christie's London and New York Branches as International; Relative Indices Initial Values)

This figure presents the art price indices of local and international markets (Sotheby's & Christie's London and New York branches as International) since 1970 detailed in Online Appendix 18. The observations are defined as International when the observations were sold at Sotheby's London, Sotheby's New York, Christie's London or Christie's New York and the observations are defined as Local otherwise. The starting points of the indices are adjusted by the average price of the subsamples from 1970 to 1974.



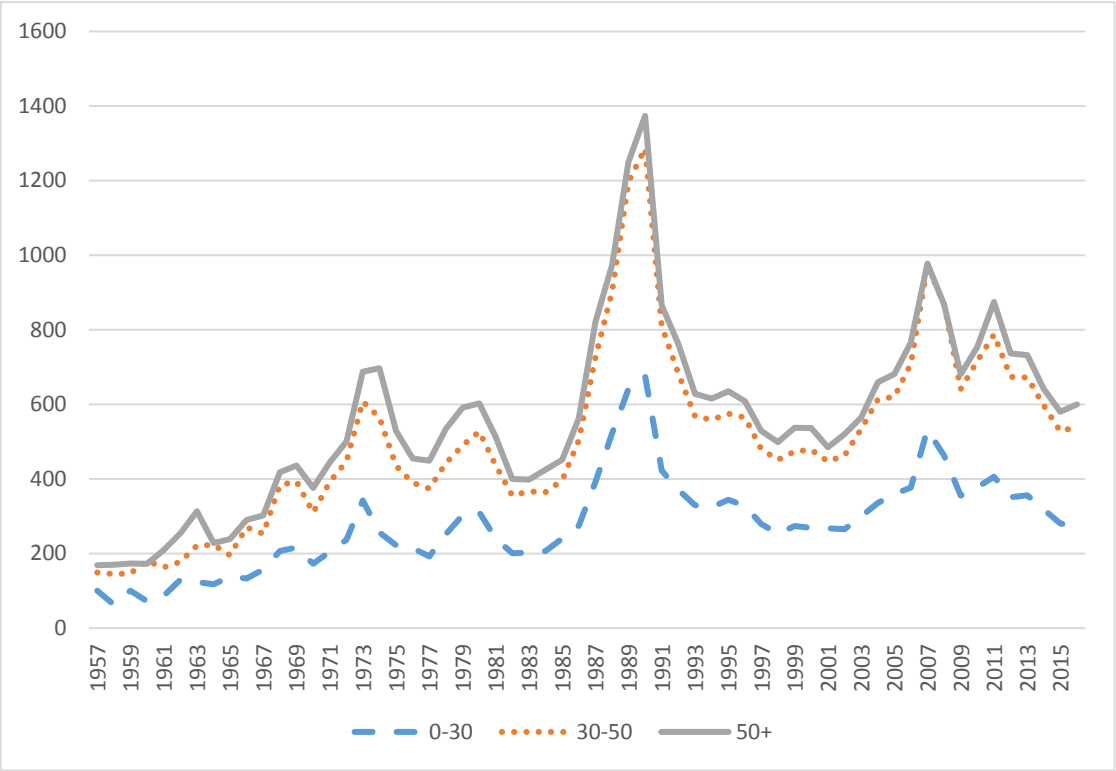
Appendix X Price Indices of Artist Life Cycle since 1957 (Indices Initial Values = 100)

This figure presents the art price indices of artist life cycle since 1957 detailed in Online Appendix IV. The observations are classified into three subsamples by the age when the artist created the paintings: (1) below (equal to) 30; (2) above 30 and below (equal to) 50; and (3) above 50. The initial indices values are set to be 100 in year 1957.



Appendix XI Price Indices of Artist Life Cycle since 1957 (Relative Indices Initial Values)

This figure presents the art price indices of artist life cycle since 1957 detailed in Appendix II. The observations are classified into three subsamples by the age when the artist created the paintings: (1) below (equal to) 30; (2) above 30 and below (equal to) 50; and (3) above 50. The initial index value for below-30 group is set to be 100 in 1957 and the initial indices values for other age groups are normalized by the average price from 1957 to 1961 relative to below-30 group's.



Online Appendix

Online Appendix 1 Hedonic Regressions by Art Movements

This table presents the hedonic regression results per movement since 1957. Eq. (1) is estimated using OLS. The dependent variable is the natural log of deflated hammer price. We run regressions on thirteen subsamples of movements: (1) Medieval & Renaissance; (2) Baroque; and (3) Rococo; (4) Neoclassicism; (5) Romanticism; (6) Realism; (7) Impressionism & Symbolism; (8) Fauvism & Expressionism; (9) Cubism, Futurism & Constructivism; (10) Dada & Surrealism; (11) Abstract Expressionism; (12) Pop; (13) Minimalism & Contemporary. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors are clustered at auction branch level and reported in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Variables	Medieval and Renaissance	Baroque	Rococo	Neoclassicism	Romanticism	Realism	Impressionism and Symbolism	Fauvism and Expressionism	Cubism Futurism and Constructivism	Dada and Surrealism	Abstract Expressionism	Pop	Minimalism and Contemporary
Abstract	-0.042	0.155	0.217	-0.087	-0.069	-0.210***	-0.184	-0.099***	0.151***	-0.057***	0.045***	-0.070	-0.033
	(0.298)	(0.138)	(0.253)	(0.245)	(0.235)	(0.057)	(0.112)	(0.035)	(0.019)	(0.017)	(0.015)	(0.048)	(0.040)
Animals	0.073	-0.111***	0.017	-0.012	-0.055***	-0.057***	-0.101***	-0.059***	-0.147***	-0.077***	0.062**	-0.073	-0.077*
	(0.048)	(0.013)	(0.033)	(0.073)	(0.021)	(0.022)	(0.018)	(0.020)	(0.023)	(0.020)	(0.025)	(0.048)	(0.046)
Landscape	0.041	-0.033***	-0.053**	-0.084*	-0.017	-0.002	0.008	0.016	-0.049***	-0.052**	0.095***	0.032	0.024
	(0.029)	(0.011)	(0.025)	(0.047)	(0.018)	(0.015)	(0.012)	(0.013)	(0.018)	(0.022)	(0.023)	(0.033)	(0.035)
Seascape	-0.110	-0.089***	0.027	0.119	-0.022	0.089***	0.159***	0.173***	0.102***	0.104***	0.316***	0.057	-0.144**
	(0.102)	(0.019)	(0.057)	(0.100)	(0.023)	(0.021)	(0.014)	(0.017)	(0.025)	(0.034)	(0.037)	(0.047)	(0.062)
Urbanscape	0.018	0.061***	0.059*	0.248***	0.112***	0.102***	0.120***	0.108***	0.134***	0.017	0.081***	0.133***	0.006
	(0.033)	(0.013)	(0.032)	(0.049)	(0.020)	(0.016)	(0.013)	(0.014)	(0.019)	(0.024)	(0.029)	(0.036)	(0.032)
Nude	0.006	-0.014	-0.147**	-0.386***	-0.194***	-0.248***	-0.154***	-0.041**	-0.073***	-0.110***	-0.429***	0.318***	0.056
	(0.067)	(0.045)	(0.068)	(0.081)	(0.050)	(0.021)	(0.020)	(0.016)	(0.024)	(0.023)	(0.040)	(0.041)	(0.053)
People	0.021	-0.037***	-0.054***	-0.189***	-0.091***	0.034**	0.033***	0.024*	0.123***	0.175***	0.035	0.233***	0.031
	(0.016)	(0.009)	(0.018)	(0.029)	(0.019)	(0.015)	(0.012)	(0.013)	(0.017)	(0.015)	(0.024)	(0.037)	(0.031)
Self Portrait	0.633***	0.216**	0.188	0.024	0.262*	0.313***	0.200***	0.443***	0.098	0.209***	-0.122	1.072***	0.353***
	(0.242)	(0.096)	(0.130)	(0.111)	(0.138)	(0.051)	(0.048)	(0.045)	(0.064)	(0.049)	(0.080)	(0.101)	(0.076)
Portrait	0.002	-0.187***	-0.099***	-0.003	-0.104***	-0.238***	-0.234***	-0.183***	-0.155***	-0.004	-0.212***	0.190***	0.003
	(0.029)	(0.015)	(0.026)	(0.036)	(0.028)	(0.020)	(0.017)	(0.019)	(0.026)	(0.023)	(0.038)	(0.042)	(0.056)
Religion	-0.029	-0.118***	-0.088***	-0.202***	-0.100**	-0.090**	0.042**	0.122***	-0.149***	-0.027	0.186***	-0.144**	0.008
	(0.022)	(0.012)	(0.027)	(0.047)	(0.040)	(0.036)	(0.021)	(0.025)	(0.040)	(0.036)	(0.048)	(0.071)	(0.051)
Still Life	0.027	0.165***	-0.028	0.002	-0.076*	0.279***	0.064***	0.026*	0.202***	0.093***	0.132***	0.307***	-0.168***
	(0.069)	(0.017)	(0.042)	(0.082)	(0.043)	(0.022)	(0.017)	(0.015)	(0.018)	(0.021)	(0.029)	(0.040)	(0.046)
Study	-0.038	-0.012	-0.173***	-0.225***	-0.193***	-0.196***	-0.318***	-0.196***	0.002	-0.170***	-0.119***	0.246***	-0.025
	(0.042)	(0.024)	(0.040)	(0.049)	(0.029)	(0.021)	(0.018)	(0.026)	(0.026)	(0.028)	(0.043)	(0.036)	(0.039)
Other Topic	-0.057**	-0.062***	-0.023	-0.054	0.046**	0.146***	0.092***	0.087***	0.079***	0.089***	0.168***	0.140***	0.066***
	(0.025)	(0.011)	(0.024)	(0.038)	(0.019)	(0.015)	(0.012)	(0.014)	(0.016)	(0.014)	(0.012)	(0.021)	(0.015)
Height	0.004***	0.002***	0.005***	0.006***	0.005***	0.015***	0.019***	0.016***	0.016***	0.011***	0.010***	0.008***	0.006***
	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)	(0.000)
Width	0.006***	0.007***	0.007***	0.011***	0.011***	0.009***	0.016***	0.008***	0.009***	0.009***	0.008***	0.006***	0.010***
	(0.001)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)
Height_Sqr	-0.000***	-0.000***	-0.000**	-0.000***	-0.000**	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***	0.000	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Width_Sqr	-0.000***	-0.000***	-0.000***	-0.000***	-0.000**	-0.000	-0.000***	0.000***	-0.000	-0.000***	-0.000***	-0.000***	-0.000***

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Variables	Medieval and Renaissance	Baroque	Rococo	Neoclassicism	Romanticism	Realism	Impressionism and Symbolism	Fauvism and Expressionism	Cubism Futurism and Constructivism	Dada and Surrealism	Abstract Expressionism	Pop	Minimalism and Contemporary
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Oil	0.712***	0.962***	0.946***	0.974***	1.206***	1.289***	1.283***	1.691***	1.309***	1.294***	0.820***	0.727***	0.682***
	(0.026)	(0.012)	(0.021)	(0.033)	(0.020)	(0.014)	(0.012)	(0.013)	(0.017)	(0.013)	(0.012)	(0.019)	(0.016)
Watercolor	0.259***	0.153***	0.251***	0.275***	0.633***	0.628***	0.531***	0.728***	0.574***	0.582***	0.295***	0.194***	0.147***
	(0.055)	(0.028)	(0.032)	(0.037)	(0.021)	(0.013)	(0.011)	(0.009)	(0.012)	(0.011)	(0.013)	(0.021)	(0.017)
Signed	0.282***	0.263***	0.107***	0.247***	0.145***	0.298***	0.321***	0.305***	0.230***	0.242***	0.171***	0.097***	-0.094***
	(0.034)	(0.010)	(0.024)	(0.028)	(0.013)	(0.011)	(0.008)	(0.009)	(0.012)	(0.012)	(0.014)	(0.021)	(0.018)
Dated	0.229***	0.276***	0.248***	0.273***	0.283***	0.231***	0.193***	0.084***	0.138***	0.182***	0.061***	0.304***	0.223***
	(0.030)	(0.012)	(0.027)	(0.032)	(0.013)	(0.010)	(0.008)	(0.009)	(0.010)	(0.009)	(0.010)	(0.018)	(0.017)
Inscribed	0.031	0.025**	0.004	0.039	-0.022	0.008	-0.013	-0.016	-0.113***	-0.051***	0.005	-0.010	-0.015
	(0.020)	(0.011)	(0.023)	(0.028)	(0.016)	(0.012)	(0.010)	(0.010)	(0.013)	(0.012)	(0.011)	(0.016)	(0.015)
Attributed	-0.676***	-0.692***	-0.936***	-0.727***	-1.072***	-1.241***	-1.333***	-1.578***	-1.577***	-1.456***	-1.845***	-2.371***	-1.714***
	(0.018)	(0.008)	(0.017)	(0.026)	(0.019)	(0.028)	(0.032)	(0.080)	(0.094)	(0.090)	(0.161)	(0.416)	(0.375)
Studio	-0.722***	-0.648***	-0.975***	-0.782***	-1.000***	-1.580***	-1.407***	-1.977***	-0.873***	-0.973***		-1.178***	
	(0.028)	(0.016)	(0.035)	(0.053)	(0.058)	(0.139)	(0.312)	(0.097)	(0.083)	(0.081)		(0.087)	
Circle	-0.969***	-0.946***	-1.247***	-1.130***	-1.522***	-1.693***	-1.831***	-2.474***	-0.053				
	(0.020)	(0.009)	(0.022)	(0.040)	(0.035)	(0.083)	(0.179)	(0.313)	(0.039)				
School	-1.205***	-1.193***	-1.596***	-1.284***	-1.815***	-2.236***	-2.455***	-2.684***	-2.439***	-3.191***			
	(0.031)	(0.015)	(0.030)	(0.068)	(0.047)	(0.128)	(0.181)	(0.127)	(0.588)	(0.055)			
After	-1.832***	-1.643***	-1.990***	-1.720***	-2.225***	-2.175***	-2.320***	-2.890***	-1.839***	-2.469***	-1.899**	-1.020**	-1.907***
	(0.030)	(0.015)	(0.031)	(0.062)	(0.045)	(0.098)	(0.179)	(0.587)	(0.437)	(0.148)	(0.904)	(0.492)	(0.081)
Style	-1.607***	-1.444***	-1.908***	-1.653***	-2.074***	-2.257***	-2.514***	-1.639**	-1.799***	-1.978***	-0.980*		
	(0.023)	(0.009)	(0.022)	(0.045)	(0.033)	(0.071)	(0.117)	(0.645)	(0.503)	(0.460)	(0.523)		
Deceased						0.011	-0.605	0.154***	-0.017	-0.088***	0.034**	0.042*	0.379***
						(0.026)	(0.439)	(0.025)	(0.024)	(0.016)	(0.015)	(0.025)	(0.029)
Sotheby's London	0.588***	0.492***	0.588***	0.607***	0.795***	0.714***	0.680***	0.592***	0.622***	0.632***	0.536***	0.924***	0.917***
	(0.022)	(0.010)	(0.023)	(0.036)	(0.021)	(0.016)	(0.012)	(0.012)	(0.015)	(0.015)	(0.018)	(0.029)	(0.026)
Sotheby's New York	0.551***	0.531***	0.539***	0.773***	0.699***	0.753***	0.657***	0.471***	0.611***	0.621***	0.369***	0.620***	0.633***
	(0.028)	(0.013)	(0.027)	(0.041)	(0.019)	(0.015)	(0.012)	(0.013)	(0.015)	(0.016)	(0.017)	(0.027)	(0.023)
Sotheby's Other Branches	0.350***	0.322***	0.409***	0.388***	0.439***	0.198***	0.250***	0.182***	0.271***	0.352***	0.149***	0.112**	0.160***
	(0.027)	(0.012)	(0.028)	(0.043)	(0.029)	(0.024)	(0.019)	(0.020)	(0.024)	(0.025)	(0.022)	(0.044)	(0.030)
Christie's London	0.496***	0.510***	0.525***	0.588***	0.753***	0.693***	0.616***	0.545***	0.644***	0.680***	0.501***	0.868***	0.841***
	(0.023)	(0.010)	(0.022)	(0.036)	(0.022)	(0.018)	(0.014)	(0.014)	(0.019)	(0.018)	(0.020)	(0.031)	(0.028)
Christie's New York	0.392***	0.375***	0.384***	0.578***	0.629***	0.610***	0.571***	0.362***	0.481***	0.519***	0.319***	0.407***	0.551***
	(0.032)	(0.015)	(0.030)	(0.050)	(0.021)	(0.017)	(0.015)	(0.015)	(0.020)	(0.019)	(0.019)	(0.028)	(0.025)
Christie's Other Branches	0.084***	0.103***	0.128***	0.218***	0.310***	0.191***	0.243***	0.063***	0.149***	0.166***	0.076***	0.361***	0.167***
	(0.022)	(0.010)	(0.022)	(0.035)	(0.022)	(0.018)	(0.015)	(0.016)	(0.019)	(0.020)	(0.017)	(0.032)	(0.024)
Bonhams London	-0.159***	-0.239***	-0.180***	-0.229**	0.208***	0.210***	0.193***	-0.052	0.240**	0.264***	0.290***	0.361**	0.392***
	(0.061)	(0.023)	(0.056)	(0.103)	(0.060)	(0.047)	(0.053)	(0.059)	(0.098)	(0.096)	(0.072)	(0.145)	(0.128)
Bonhams Other Branches	-0.047	-0.038	-0.150*	-0.108	0.091*	0.157***	0.069*	-0.132***	-0.029	-0.039	-0.007	-0.235***	-0.346***
	(0.074)	(0.036)	(0.086)	(0.133)	(0.048)	(0.037)	(0.041)	(0.051)	(0.060)	(0.070)	(0.047)	(0.081)	(0.060)
Phillips London	0.043	0.016	-0.028	0.200***	0.201***	0.245***	0.171***	0.116**	0.104	0.110	0.136**	0.543***	0.514***
	(0.035)	(0.016)	(0.040)	(0.069)	(0.047)	(0.041)	(0.046)	(0.053)	(0.068)	(0.071)	(0.061)	(0.082)	(0.053)
Phillips New York	0.085	-0.084	-0.542***	0.210	0.472***	0.303***	0.300***	0.417***	0.221**	0.204**	0.062	0.351***	0.377***
	(0.119)	(0.067)	(0.152)	(0.373)	(0.074)	(0.058)	(0.052)	(0.075)	(0.100)	(0.096)	(0.060)	(0.059)	(0.037)

Variables	(1) Medieval and Renaissance	(2) Baroque	(3) Rococo	(4) Neoclassicism	(5) Romanticism	(6) Realism	(7) Impressionism and Symbolism	(8) Fauvism and Expressionism	(9) Cubism Futurism and Constructivism	(10) Dada and Surrealism	(11) Abstract Expressionism	(12) Pop	(13) Minimalism and Contemporary
Auction_American	-0.476***	-0.263***	-0.226***	-0.185***	0.008	-0.055***	-0.032*	-0.205***	-0.273***	-0.276***	-0.247***	-0.362***	-0.374***
	(0.050)	(0.022)	(0.041)	(0.062)	(0.022)	(0.021)	(0.018)	(0.030)	(0.034)	(0.040)	(0.028)	(0.064)	(0.058)
Auction_European	0.266***	0.264***	0.297***	0.187***	0.249***	0.148***	0.110***	0.057***	0.095***	0.087***	-0.039***	0.097***	0.160***
	(0.020)	(0.009)	(0.019)	(0.029)	(0.018)	(0.014)	(0.010)	(0.010)	(0.012)	(0.012)	(0.014)	(0.021)	(0.021)
Pedigree	0.140***	0.251***	0.320***	0.219***	0.420***	0.321***	0.319***	0.320***	0.294***	0.306***	0.294***	0.475***	0.319***
	(0.023)	(0.011)	(0.023)	(0.036)	(0.018)	(0.014)	(0.011)	(0.011)	(0.014)	(0.014)	(0.013)	(0.020)	(0.017)
Exhibition	0.530***	0.518***	0.426***	0.428***	0.421***	0.435***	0.475***	0.356***	0.379***	0.422***	0.258***	0.500***	0.348***
	(0.040)	(0.022)	(0.039)	(0.056)	(0.027)	(0.019)	(0.014)	(0.015)	(0.017)	(0.017)	(0.016)	(0.026)	(0.020)
Literature	0.512***	0.475***	0.552***	0.557***	0.355***	0.477***	0.275***	0.342***	0.435***	0.446***	0.523***	0.365***	0.492***
	(0.032)	(0.017)	(0.033)	(0.048)	(0.026)	(0.019)	(0.013)	(0.015)	(0.017)	(0.016)	(0.018)	(0.026)	(0.025)
Authentication	-0.257**	0.193***	0.364***	-0.139	0.530***	0.150***	0.181***	0.123***	0.077***	0.064**	-0.054*	0.034	0.353***
	(0.104)	(0.047)	(0.133)	(0.175)	(0.085)	(0.038)	(0.032)	(0.026)	(0.025)	(0.029)	(0.030)	(0.050)	(0.039)
Constant	7.998***	6.623***	6.965***	5.230***	5.515***	5.754***	5.637***	5.387***	5.332***	5.363***	5.350***	5.721***	5.598***
	(0.135)	(0.067)	(0.126)	(0.195)	(0.140)	(0.136)	(0.433)	(0.169)	(0.227)	(0.242)	(0.905)	(0.167)	(0.105)
Observations	35,011	141,158	34,567	15,157	50,434	73,758	117,075	90,837	62,253	63,154	49,651	27,106	31,014
R-squared	0.568	0.547	0.545	0.560	0.610	0.680	0.736	0.738	0.740	0.738	0.717	0.717	0.737
Artist FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Online Appendix 2 Hedonic Regressions of Top Artists by Art Movements

This table presents the hedonic regression results of movements by top artists since 1957. Eq. (1) is estimated using OLS. The dependent variable is the natural log of deflated hammer price. We select top 20 artists for each movement by the magnitude of artists' coefficients. We run regressions on thirteen subsamples of movements: (1) Medieval & Renaissance; (2) Baroque; and (3) Rococo; (4) Neoclassicism; (5) Romanticism; (6) Realism; (7) Impressionism & Symbolism; (8) Fauvism & Expressionism; (9) Cubism, Futurism & Constructivism; (10) Dada & Surrealism; (11) Abstract Expressionism; (12) Pop; (13) Minimalism & Contemporary. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors are clustered at auction branch level and reported in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Variables	Medieval and Renaissance	Baroque	Rococo	Neoclassicism	Romanticism	Realism	Impressionism and Symbolism	Fauvism and Expressionism	Cubism Futurism and Constructivism	Dada and Surrealism	Abstract Expressionism	Pop	Minimalism and Contemporary
Abstract			0.092	-1.357***	-0.212	-0.865***	-1.440***	0.164***	0.133***	-0.255***	0.059*	-0.047	-0.165
			(0.562)	(0.308)	(0.628)	(0.314)	(0.442)	(0.063)	(0.040)	(0.041)	(0.036)	(0.074)	(0.157)
Animals	0.443**	-0.177	0.099	-0.001	-0.062	-0.097*	-0.241***	-0.078	-0.262***	-0.136***	-0.642***	0.023	-0.303***
	(0.222)	(0.112)	(0.075)	(0.151)	(0.078)	(0.050)	(0.057)	(0.051)	(0.036)	(0.032)	(0.113)	(0.058)	(0.095)
Landscape	0.049	-0.016	-0.167***	-0.144	-0.111*	-0.079**	-0.116***	0.062*	-0.217***	0.016	0.064	0.087**	-0.043
	(0.166)	(0.072)	(0.052)	(0.108)	(0.060)	(0.032)	(0.035)	(0.037)	(0.041)	(0.046)	(0.066)	(0.041)	(0.063)
Seascape	-0.178	0.033	-0.023	-0.176	-0.081	0.032	0.043	0.005	0.132***	0.332***	0.295**	0.070	-0.107
	(0.957)	(0.161)	(0.110)	(0.281)	(0.077)	(0.053)	(0.053)	(0.054)	(0.046)	(0.053)	(0.129)	(0.055)	(0.102)
Urbanscape	-0.035	0.183**	0.059	0.261**	0.070	0.093***	-0.108**	-0.041	0.199***	0.083*	0.078	0.151***	-0.008
	(0.176)	(0.086)	(0.056)	(0.103)	(0.059)	(0.032)	(0.048)	(0.051)	(0.039)	(0.049)	(0.082)	(0.045)	(0.063)
Nude	0.335	1.433***	-0.027	-0.475***	-0.273**	-0.198***	-0.189***	0.035	-0.014	0.018	-1.123***	0.392***	-0.162
	(0.392)	(0.201)	(0.108)	(0.150)	(0.131)	(0.063)	(0.049)	(0.042)	(0.041)	(0.042)	(0.094)	(0.046)	(0.127)
People	-0.358	-0.086	0.018	-0.238***	-0.181**	0.080**	0.007	0.078**	0.184***	0.225***	0.293***	0.296***	0.023
	(0.243)	(0.072)	(0.041)	(0.061)	(0.071)	(0.037)	(0.033)	(0.033)	(0.030)	(0.029)	(0.075)	(0.048)	(0.084)
Self Portrait		-0.704	0.509*	-0.196	-0.013	0.846***	0.454*	1.123***	0.008	0.169*	-0.085	1.422***	0.696***
		(1.516)	(0.310)	(0.174)	(0.445)	(0.164)	(0.254)	(0.123)	(0.096)	(0.096)	(0.224)	(0.122)	(0.192)
Portrait	-0.700	-0.209	-0.148***	-0.060	0.137	-0.241***	0.014	-0.066*	-0.306***	-0.161***	-0.649***	0.181***	-0.158
	(0.954)	(0.147)	(0.053)	(0.076)	(0.105)	(0.049)	(0.041)	(0.039)	(0.054)	(0.051)	(0.154)	(0.061)	(0.114)
Religion	-0.034	0.101	-0.082	-0.202**	-0.063	-0.239***	0.024	0.030	-0.050	0.128	0.191*	-0.188**	-0.204
	(0.207)	(0.080)	(0.051)	(0.098)	(0.104)	(0.091)	(0.055)	(0.061)	(0.066)	(0.111)	(0.111)	(0.088)	(0.157)
Still Life	-0.496	0.085	-0.033	0.119	-0.155	0.073	0.161***	0.122***	0.207***	0.061	0.168**	0.388***	-0.381***
	(0.550)	(0.103)	(0.081)	(0.148)	(0.130)	(0.045)	(0.042)	(0.040)	(0.031)	(0.039)	(0.083)	(0.046)	(0.120)
Study	-0.260	-0.197*	-0.213***	-0.291***	-0.317***	-0.391***	-0.473***	-0.121	0.046	-0.152**	-0.141	0.370***	-0.276***
	(0.367)	(0.102)	(0.064)	(0.093)	(0.082)	(0.046)	(0.041)	(0.079)	(0.049)	(0.060)	(0.086)	(0.045)	(0.087)
Other Topic	-0.236	-0.108	-0.037	-0.122	0.031	0.185***	0.060*	0.080**	0.066**	0.071**	0.154***	0.209***	0.041
	(0.198)	(0.084)	(0.047)	(0.079)	(0.065)	(0.037)	(0.036)	(0.034)	(0.030)	(0.028)	(0.029)	(0.028)	(0.043)
Height	0.013*	0.003	0.008***	0.014***	0.009***	0.025***	0.034***	0.021***	0.027***	0.016***	0.013***	0.009***	0.029***
	(0.008)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)
Width	0.009*	0.004**	0.011***	0.011***	0.015***	0.015***	0.019***	0.008***	0.013***	0.013***	0.018***	0.006***	0.007***
	(0.005)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.003)	(0.002)	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)
Height_Sqr	-0.000	-0.000	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***	-0.000	-0.000***	-0.000***	-0.000***	0.000	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Width_Sqr	-0.000*	-0.000**	-0.000***	-0.000***	-0.000*	-0.000**	-0.000***	-0.000	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Oil	0.264	1.411***	0.776***	0.831***	1.293***	1.408***	1.165***	1.850***	1.371***	1.444***	0.680***	0.716***	0.784***
	(0.400)	(0.082)	(0.039)	(0.063)	(0.058)	(0.034)	(0.030)	(0.034)	(0.023)	(0.027)	(0.027)	(0.023)	(0.038)
Watercolor	-0.659	-0.085	0.124	0.314***	1.049***	0.919***	0.518***	1.078***	0.636***	0.870***	0.238***	0.221***	0.248***

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Variables	Medieval and Renaissance	Baroque	Rococo	Neoclassicism	Romanticism	Realism	Impressionism and Symbolism	Fauvism and Expressionism	Cubism Futurism and Constructivism	Dada and Surrealism	Abstract Expressionism	Pop	Minimalism and Contemporary
	(0.621)	(0.135)	(0.088)	(0.102)	(0.060)	(0.034)	(0.037)	(0.026)	(0.019)	(0.025)	(0.034)	(0.027)	(0.047)
Signed	0.251**	0.418***	0.268***	0.531***	0.240***	0.494***	0.523***	0.173***	0.258***	0.375***	0.346***	0.057**	-0.197***
	(0.124)	(0.080)	(0.049)	(0.060)	(0.039)	(0.028)	(0.023)	(0.023)	(0.019)	(0.025)	(0.033)	(0.025)	(0.046)
Dated	0.106	0.335***	0.354***	0.376***	0.205***	0.306***	0.035	0.078***	0.093***	0.175***	-0.103***	0.476***	0.449***
	(0.135)	(0.090)	(0.070)	(0.069)	(0.053)	(0.034)	(0.031)	(0.022)	(0.017)	(0.020)	(0.023)	(0.026)	(0.047)
Inscribed	-0.079	-0.048	-0.108**	-0.001	0.010	0.073**	-0.079*	-0.086***	-0.159***	-0.106***	0.244***	0.005	-0.149***
	(0.198)	(0.087)	(0.047)	(0.059)	(0.050)	(0.036)	(0.041)	(0.023)	(0.020)	(0.022)	(0.028)	(0.021)	(0.042)
Attributed	-1.314***	-1.187***	-1.348***	-0.977***	-2.150***	-2.017***	-2.134***	-1.981***	-2.160***	-1.567***	-1.403***	-2.234***	-3.447***
	(0.217)	(0.093)	(0.042)	(0.059)	(0.068)	(0.062)	(0.104)	(0.192)	(0.144)	(0.184)	(0.372)	(0.432)	(0.608)
Studio	-1.694***	-1.342***	-1.278***	-0.946***	-2.458***	-2.645***	-2.694***	-2.225***				-0.930***	
	(0.145)	(0.097)	(0.067)	(0.073)	(0.276)	(0.285)	(0.321)	(0.135)				(0.108)	
Circle	-2.547***	-1.716***	-1.669***	-1.360***	-2.718***	-2.360***	-3.254***	-3.996***					
	(0.182)	(0.075)	(0.049)	(0.071)	(0.108)	(0.139)	(0.327)	(0.442)					
School	-2.066***	-2.170***	-1.922***	-1.502***	-2.929***	-2.638***	-3.689***		-1.840***				
	(0.217)	(0.148)	(0.053)	(0.097)	(0.141)	(0.174)	(0.201)		(0.124)				
After	-3.455***	-2.574***	-2.372***	-2.126***	-3.435***	-3.327***	-3.389***	-3.843***	-1.534***	-1.852***		-1.021***	-1.474***
	(0.239)	(0.101)	(0.049)	(0.097)	(0.096)	(0.161)	(0.381)	(0.530)	(0.461)	(0.544)		(0.366)	(0.156)
Style	-2.869***	-2.320***	-2.390***	-1.987***	-3.518***	-3.072***	-3.493***	-2.483**	-3.262***	-1.705*			
	(0.193)	(0.074)	(0.042)	(0.068)	(0.089)	(0.106)	(0.340)	(1.103)	(0.075)	(0.949)			
Deceased						0.794***	-0.654***	0.610***	-0.235***	-0.142***	-0.178***	0.149***	0.341***
						(0.229)	(0.155)	(0.192)	(0.036)	(0.047)	(0.039)	(0.033)	(0.062)
Sotheby's London	0.928***	0.791***	0.703***	0.709***	0.794***	0.675***	0.734***	0.503***	0.569***	0.666***	0.697***	0.930***	0.874***
	(0.163)	(0.084)	(0.047)	(0.070)	(0.066)	(0.034)	(0.033)	(0.029)	(0.025)	(0.030)	(0.038)	(0.036)	(0.072)
Sotheby's New York	1.057***	0.893***	0.722***	0.833***	0.763***	0.779***	0.810***	0.394***	0.562***	0.644***	0.449***	0.528***	0.493***
	(0.228)	(0.107)	(0.051)	(0.070)	(0.064)	(0.034)	(0.037)	(0.033)	(0.027)	(0.033)	(0.045)	(0.034)	(0.078)
Sotheby's Other Branches	0.575**	0.547***	0.370***	0.393***	0.149	0.168*	0.135	0.054	0.154***	0.269***	-0.081	-0.103	-0.097
	(0.265)	(0.104)	(0.057)	(0.087)	(0.129)	(0.089)	(0.111)	(0.068)	(0.052)	(0.055)	(0.051)	(0.064)	(0.077)
Christie's London	0.804***	0.800***	0.484***	0.587***	0.669***	0.535***	0.639***	0.436***	0.631***	0.688***	0.645***	0.861***	0.806***
	(0.163)	(0.083)	(0.045)	(0.068)	(0.063)	(0.036)	(0.035)	(0.032)	(0.028)	(0.033)	(0.041)	(0.038)	(0.079)
Christie's New York	0.555**	0.742***	0.462***	0.672***	0.612***	0.706***	0.744***	0.282***	0.478***	0.596***	0.391***	0.329***	0.512***
	(0.216)	(0.124)	(0.058)	(0.085)	(0.072)	(0.039)	(0.042)	(0.037)	(0.032)	(0.038)	(0.050)	(0.035)	(0.081)
Christie's Other Branches	0.658***	0.284***	0.166***	0.287***	0.410***	0.349***	0.434***	-0.009	0.082**	0.098**	0.035	0.388***	-0.038
	(0.211)	(0.092)	(0.045)	(0.072)	(0.083)	(0.054)	(0.053)	(0.057)	(0.039)	(0.041)	(0.050)	(0.045)	(0.067)
Bonhams London	-0.459	-0.162	-0.256**	-0.138	-0.053	-0.425*	0.202	-0.324	-0.135	-0.422	0.515*	0.408**	1.017***
	(0.410)	(0.317)	(0.114)	(0.213)	(0.175)	(0.241)	(0.135)	(0.217)	(0.199)	(0.274)	(0.306)	(0.177)	(0.305)
Bonhams Other Branches	-0.054	-0.150	-0.047	0.249	0.103	0.386	-0.332	-0.686***	-0.024	-0.275	0.095	-0.701***	-1.042***
	(0.709)	(0.320)	(0.183)	(0.361)	(0.271)	(0.337)	(0.203)	(0.180)	(0.192)	(0.315)	(0.187)	(0.144)	(0.171)
Phillips London	0.969***	0.126	-0.093	0.098	-0.366**	-0.032	-0.155	0.295	-0.304	-0.426**	0.143	0.630***	0.185
	(0.323)	(0.209)	(0.091)	(0.126)	(0.175)	(0.145)	(0.228)	(0.342)	(0.194)	(0.189)	(0.199)	(0.104)	(0.162)
Phillips New York			-0.839***	-0.350	0.153	0.455**	1.047***	0.534***	0.002	-0.131	0.130	0.267***	0.297***
			(0.190)	(0.235)	(0.284)	(0.209)	(0.156)	(0.135)	(0.175)	(0.160)	(0.112)	(0.067)	(0.107)
Auction_American	-0.195	-0.580**	-0.137**	-0.187*	0.085	-0.076	-0.276**	0.077	-0.415***	-0.269**	-0.865***	-0.578***	-0.624***
	(0.253)	(0.281)	(0.067)	(0.113)	(0.095)	(0.073)	(0.117)	(0.095)	(0.075)	(0.104)	(0.119)	(0.091)	(0.236)
Auction_European	0.514***	0.513***	0.389***	0.296***	0.314***	0.200***	0.221***	-0.059*	0.003	0.161***	0.049	0.086**	0.094
	(0.174)	(0.083)	(0.040)	(0.063)	(0.079)	(0.034)	(0.040)	(0.031)	(0.028)	(0.032)	(0.036)	(0.038)	(0.106)
Pedigree	0.013	0.112	0.365***	0.189***	0.291***	0.180***	0.097***	0.193***	0.290***	0.340***	0.390***	0.538***	0.431***
	(0.147)	(0.069)	(0.044)	(0.073)	(0.061)	(0.033)	(0.037)	(0.032)	(0.026)	(0.031)	(0.037)	(0.027)	(0.052)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Variables	Medieval and Renaissance	Baroque	Rococo	Neoclassicism	Romanticism	Realism	Impressionism and Symbolism	Fauvism and Expressionism	Cubism Futurism and Constructivism	Dada and Surrealism	Abstract Expressionism	Pop	Minimalism and Contemporary
Exhibition	0.477***	0.578***	0.484***	0.348***	0.496***	0.544***	0.517***	0.371***	0.331***	0.392***	0.147***	0.534***	0.428***
	(0.178)	(0.086)	(0.067)	(0.094)	(0.062)	(0.038)	(0.030)	(0.032)	(0.025)	(0.027)	(0.034)	(0.031)	(0.042)
Literature	0.309**	0.303***	0.541***	0.687***	0.180***	0.422***	0.241***	0.282***	0.489***	0.470***	0.471***	0.317***	0.174***
	(0.138)	(0.079)	(0.055)	(0.082)	(0.062)	(0.036)	(0.031)	(0.032)	(0.026)	(0.027)	(0.034)	(0.032)	(0.043)
Authentication	0.097	0.451*	0.507*	-0.204	0.439**	-0.001	0.243***	0.021	0.196***	0.052	-0.184*	0.126	0.355***
	(0.445)	(0.241)	(0.283)	(0.269)	(0.215)	(0.084)	(0.087)	(0.060)	(0.049)	(0.055)	(0.106)	(0.091)	(0.122)
Constant	9.101***	7.986***	7.259***	5.344***	7.390***	5.929***	6.385***	4.626***	6.310***	6.066***	5.523***	5.785***	5.690***
	(0.520)	(0.391)	(0.196)	(0.355)	(0.300)	(0.287)	(0.210)	(0.662)	(0.240)	(0.545)	(0.192)	(0.210)	(0.380)
Observations	804	3,429	11,141	4,591	6,365	14,763	15,828	16,084	22,881	18,232	11,276	17,324	5,527
R-squared	0.752	0.602	0.538	0.556	0.597	0.640	0.690	0.656	0.684	0.674	0.713	0.657	0.700
Artist FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Online Appendix 3 Hedonic Regressions by Art Movements since 1970

This table presents the hedonic regression results of movements since 1970. Eq. (1) is estimated using OLS. The dependent variable is the natural log of deflated hammer price. We run regressions on thirteen subsamples of movements: (1) Medieval & Renaissance; (2) Baroque; and (3) Rococo; (4) Neoclassicism; (5) Romanticism; (6) Realism; (7) Impressionism & Symbolism; (8) Fauvism & Expressionism; (9) Cubism, Futurism & Constructivism; (10) Dada & Surrealism; (11) Abstract Expressionism; (12) Pop; (13) Minimalism & Contemporary. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors are clustered at auction branch level and reported in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Variables	Medieval and Renaissance	Baroque	Rococo	Neoclassicism	Romanticism	Realism	Impressionism and Symbolism	Fauvism and Expressionism	Cubism Futurism and Constructivism	Dada and Surrealism	Abstract Expressionism	Pop	Minimalism and Contemporary
Abstract	-0.027	0.147	0.230	-0.076	-0.070	-0.207***	-0.186*	-0.100***	0.152***	-0.055***	0.044***	-0.070	-0.033
	(0.298)	(0.138)	(0.249)	(0.246)	(0.234)	(0.057)	(0.113)	(0.035)	(0.019)	(0.018)	(0.015)	(0.048)	(0.040)
Animals	0.064	-0.104***	0.020	0.002	-0.047**	-0.057***	-0.095***	-0.053***	-0.148***	-0.080***	0.060**	-0.074	-0.078*
	(0.049)	(0.014)	(0.034)	(0.075)	(0.021)	(0.022)	(0.018)	(0.020)	(0.023)	(0.020)	(0.025)	(0.049)	(0.046)
Landscape	0.045	-0.038***	-0.065**	-0.089*	-0.017	0.004	0.010	0.016	-0.048***	-0.055**	0.094***	0.030	0.024
	(0.030)	(0.012)	(0.026)	(0.048)	(0.018)	(0.015)	(0.012)	(0.013)	(0.018)	(0.022)	(0.023)	(0.033)	(0.035)
Seascape	-0.173*	-0.091***	0.011	0.120	-0.019	0.096***	0.156***	0.174***	0.103***	0.100***	0.318***	0.059	-0.144**
	(0.104)	(0.019)	(0.059)	(0.100)	(0.024)	(0.021)	(0.014)	(0.017)	(0.025)	(0.034)	(0.037)	(0.047)	(0.062)
Urbanscape	-0.012	0.059***	0.038	0.237***	0.112***	0.109***	0.120***	0.114***	0.134***	0.011	0.080***	0.131***	0.006
	(0.034)	(0.014)	(0.033)	(0.050)	(0.021)	(0.016)	(0.013)	(0.015)	(0.019)	(0.025)	(0.029)	(0.036)	(0.032)
Nude	-0.012	-0.004	-0.148**	-0.387***	-0.160***	-0.246***	-0.155***	-0.034**	-0.073***	-0.115***	-0.432***	0.317***	0.057
	(0.068)	(0.045)	(0.068)	(0.081)	(0.051)	(0.021)	(0.020)	(0.016)	(0.024)	(0.023)	(0.040)	(0.041)	(0.054)
People	0.031*	-0.042***	-0.063***	-0.190***	-0.089***	0.036**	0.032***	0.028**	0.126***	0.176***	0.035	0.232***	0.030
	(0.016)	(0.009)	(0.018)	(0.030)	(0.019)	(0.015)	(0.012)	(0.014)	(0.017)	(0.015)	(0.024)	(0.037)	(0.031)
Self Portrait	0.661**	0.213**	0.156	-0.048	0.218	0.318***	0.201***	0.448***	0.092	0.203***	-0.122	1.071***	0.353***
	(0.280)	(0.096)	(0.131)	(0.113)	(0.139)	(0.051)	(0.048)	(0.045)	(0.065)	(0.050)	(0.080)	(0.101)	(0.076)
Portrait	0.004	-0.185***	-0.104***	-0.010	-0.115***	-0.242***	-0.241***	-0.181***	-0.161***	-0.008	-0.212***	0.189***	0.006
	(0.031)	(0.016)	(0.027)	(0.037)	(0.028)	(0.020)	(0.018)	(0.019)	(0.026)	(0.023)	(0.038)	(0.042)	(0.056)
Religion	-0.021	-0.121***	-0.089***	-0.207***	-0.105***	-0.082**	0.040*	0.127***	-0.143***	-0.018	0.188***	-0.144**	0.008
	(0.022)	(0.012)	(0.027)	(0.047)	(0.040)	(0.037)	(0.021)	(0.025)	(0.040)	(0.035)	(0.048)	(0.071)	(0.051)
Still Life	0.016	0.165***	-0.003	-0.002	-0.092**	0.276***	0.064***	0.030**	0.197***	0.085***	0.130***	0.307***	-0.168***
	(0.070)	(0.017)	(0.043)	(0.082)	(0.043)	(0.022)	(0.017)	(0.015)	(0.019)	(0.021)	(0.029)	(0.040)	(0.046)
Study	-0.034	-0.011	-0.179***	-0.227***	-0.189***	-0.201***	-0.320***	-0.197***	0.000	-0.175***	-0.118***	0.246***	-0.025
	(0.043)	(0.024)	(0.041)	(0.050)	(0.029)	(0.022)	(0.018)	(0.026)	(0.026)	(0.029)	(0.043)	(0.036)	(0.039)
Other Topic	-0.053**	-0.067***	-0.032	-0.052	0.048**	0.148***	0.092***	0.090***	0.081***	0.089***	0.168***	0.140***	0.066***
	(0.025)	(0.011)	(0.024)	(0.038)	(0.020)	(0.016)	(0.013)	(0.014)	(0.016)	(0.014)	(0.012)	(0.021)	(0.015)
Height	0.004***	0.002***	0.005***	0.006***	0.005***	0.015***	0.019***	0.017***	0.016***	0.012***	0.010***	0.008***	0.006***
	(0.001)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)	(0.000)
Width	0.006***	0.007***	0.007***	0.011***	0.011***	0.009***	0.017***	0.008***	0.009***	0.010***	0.008***	0.006***	0.010***
	(0.001)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Variables	Medieval and Renaissance	Baroque	Rococo	Neoclassicism	Romanticism	Realism	Impressionism and Symbolism	Fauvism and Expressionism	Cubism Futurism and Constructivism	Dada and Surrealism	Abstract Expressionism	Pop	Minimalism and Contemporary
Height_Sqr	-0.000***	-0.000**	-0.000**	-0.000***	-0.000**	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***	0.000	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Width_Sqr	-0.000***	-0.000***	-0.000***	-0.000***	-0.000**	-0.000	-0.000***	0.000***	-0.000	-0.000***	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Oil	0.755***	0.970***	0.965***	0.980***	1.236***	1.297***	1.289***	1.689***	1.310***	1.292***	0.820***	0.726***	0.683***
	(0.027)	(0.013)	(0.022)	(0.033)	(0.020)	(0.014)	(0.012)	(0.012)	(0.016)	(0.013)	(0.012)	(0.019)	(0.016)
Watercolor	0.283***	0.146***	0.245***	0.271***	0.664***	0.634***	0.534***	0.727***	0.575***	0.582***	0.296***	0.194***	0.147***
	(0.056)	(0.029)	(0.033)	(0.037)	(0.021)	(0.013)	(0.011)	(0.009)	(0.012)	(0.011)	(0.013)	(0.021)	(0.017)
Signed	0.291***	0.259***	0.106***	0.241***	0.140***	0.296***	0.322***	0.302***	0.227***	0.238***	0.170***	0.097***	-0.094***
	(0.035)	(0.010)	(0.024)	(0.028)	(0.013)	(0.011)	(0.009)	(0.009)	(0.012)	(0.012)	(0.014)	(0.021)	(0.018)
Dated	0.236***	0.277***	0.231***	0.267***	0.287***	0.232***	0.194***	0.082***	0.140***	0.182***	0.063***	0.305***	0.223***
	(0.031)	(0.012)	(0.028)	(0.032)	(0.013)	(0.010)	(0.008)	(0.009)	(0.010)	(0.010)	(0.010)	(0.018)	(0.017)
Inscribed	0.034*	0.026**	-0.002	0.035	-0.021	0.005	-0.017*	-0.016	-0.116***	-0.053***	0.005	-0.011	-0.015
	(0.020)	(0.011)	(0.023)	(0.028)	(0.016)	(0.012)	(0.010)	(0.010)	(0.013)	(0.012)	(0.011)	(0.016)	(0.015)
Attributed	-0.681***	-0.696***	-0.943***	-0.733***	-1.074***	-1.244***	-1.331***	-1.586***	-1.580***	-1.458***	-1.844***	-2.371***	-1.714***
	(0.018)	(0.008)	(0.018)	(0.026)	(0.019)	(0.028)	(0.032)	(0.081)	(0.095)	(0.091)	(0.161)	(0.416)	(0.375)
Studio	-0.739***	-0.656***	-1.005***	-0.804***	-1.025***	-1.601***	-1.438***	-2.000***	-0.873***	-0.972***		-1.177***	
	(0.029)	(0.016)	(0.035)	(0.054)	(0.058)	(0.139)	(0.315)	(0.097)	(0.083)	(0.081)		(0.087)	
Circle	-0.984***	-0.953***	-1.270***	-1.148***	-1.540***	-1.714***	-1.876***	-2.486***	-0.042				
	(0.020)	(0.009)	(0.022)	(0.040)	(0.035)	(0.083)	(0.179)	(0.314)	(0.038)				
School	-1.234***	-1.193***	-1.621***	-1.302***	-1.836***	-2.261***	-2.576***	-2.690***	-2.453***	-3.195***			
	(0.032)	(0.015)	(0.030)	(0.068)	(0.047)	(0.129)	(0.181)	(0.128)	(0.578)	(0.055)			
After	-1.846***	-1.645***	-2.031***	-1.735***	-2.244***	-2.197***	-2.349***	-2.921***	-1.871***	-2.504***	-1.901**	-1.020**	-1.906***
	(0.031)	(0.015)	(0.032)	(0.062)	(0.046)	(0.098)	(0.180)	(0.598)	(0.435)	(0.149)	(0.904)	(0.492)	(0.081)
Style	-1.624***	-1.450***	-1.942***	-1.678***	-2.096***	-2.278***	-2.534***	-1.654**	-1.807***	-1.981***	-0.981*		
	(0.023)	(0.010)	(0.023)	(0.045)	(0.034)	(0.072)	(0.119)	(0.649)	(0.502)	(0.461)	(0.523)		
Sotheby's London	0.560***	0.480***	0.569***	0.585***	0.783***	0.680***	0.649***	0.575***	0.606***	0.618***	0.535***	0.922***	0.916***
	(0.023)	(0.010)	(0.024)	(0.037)	(0.021)	(0.017)	(0.012)	(0.012)	(0.015)	(0.015)	(0.018)	(0.029)	(0.026)
Sotheby's New York	0.544***	0.525***	0.529***	0.762***	0.692***	0.744***	0.648***	0.465***	0.605***	0.619***	0.368***	0.619***	0.632***
	(0.028)	(0.013)	(0.027)	(0.041)	(0.019)	(0.015)	(0.012)	(0.013)	(0.015)	(0.016)	(0.017)	(0.027)	(0.023)
Sotheby's Other Branches	0.347***	0.323***	0.404***	0.384***	0.433***	0.194***	0.247***	0.179***	0.268***	0.349***	0.149***	0.112**	0.160***
	(0.027)	(0.012)	(0.028)	(0.043)	(0.029)	(0.024)	(0.019)	(0.020)	(0.024)	(0.025)	(0.022)	(0.044)	(0.030)
Christie's London	0.503***	0.515***	0.546***	0.598***	0.769***	0.713***	0.633***	0.552***	0.664***	0.691***	0.503***	0.869***	0.840***
	(0.024)	(0.011)	(0.023)	(0.037)	(0.023)	(0.019)	(0.014)	(0.014)	(0.019)	(0.018)	(0.020)	(0.031)	(0.028)
Christie's New York	0.386***	0.368***	0.373***	0.567***	0.622***	0.603***	0.562***	0.356***	0.476***	0.518***	0.318***	0.406***	0.551***
	(0.032)	(0.015)	(0.030)	(0.050)	(0.021)	(0.017)	(0.015)	(0.015)	(0.020)	(0.019)	(0.019)	(0.028)	(0.025)
Christie's Other Branches	0.078***	0.102***	0.129***	0.214***	0.308***	0.187***	0.238***	0.065***	0.147***	0.165***	0.075***	0.360***	0.166***
	(0.022)	(0.010)	(0.022)	(0.035)	(0.022)	(0.018)	(0.015)	(0.016)	(0.019)	(0.020)	(0.017)	(0.032)	(0.024)
Bonhams London	-0.185***	-0.246***	-0.182***	-0.237**	0.210***	0.201***	0.185***	-0.041	0.239**	0.272***	0.290***	0.360**	0.391***
	(0.061)	(0.023)	(0.057)	(0.104)	(0.060)	(0.047)	(0.052)	(0.059)	(0.098)	(0.097)	(0.072)	(0.145)	(0.128)

Variables	(1) Medieval and Renaissance	(2) Baroque	(3) Rococo	(4) Neoclassicism	(5) Romanticism	(6) Realism	(7) Impressionism and Symbolism	(8) Fauvism and Expressionism	(9) Cubism Futurism and Constructivism	(10) Dada and Surrealism	(11) Abstract Expressionism	(12) Pop	(13) Minimalism and Contemporary
Bonhams Other Branches	-0.061	-0.045	-0.141*	-0.100	0.100**	0.154***	0.067	-0.118**	-0.020	-0.032	-0.006	-0.234***	-0.347***
	(0.074)	(0.036)	(0.085)	(0.132)	(0.048)	(0.037)	(0.041)	(0.051)	(0.060)	(0.070)	(0.048)	(0.081)	(0.060)
Phillips London	0.030	0.012	-0.024	0.196***	0.206***	0.235***	0.164***	0.129**	0.109	0.116	0.136**	0.543***	0.514***
	(0.035)	(0.016)	(0.040)	(0.069)	(0.047)	(0.041)	(0.046)	(0.053)	(0.069)	(0.071)	(0.061)	(0.082)	(0.053)
Phillips New York	0.083	-0.088	-0.546***	0.203	0.467***	0.296***	0.297***	0.410***	0.216**	0.207**	0.061	0.351***	0.377***
	(0.119)	(0.067)	(0.153)	(0.375)	(0.074)	(0.058)	(0.052)	(0.075)	(0.099)	(0.096)	(0.060)	(0.059)	(0.037)
Auction_American	-0.484***	-0.269***	-0.237***	-0.191***	0.007	-0.058***	-0.034*	-0.201***	-0.274***	-0.272***	-0.247***	-0.362***	-0.374***
	(0.050)	(0.022)	(0.041)	(0.062)	(0.022)	(0.021)	(0.018)	(0.030)	(0.034)	(0.040)	(0.028)	(0.064)	(0.058)
Auction_European	0.259***	0.262***	0.294***	0.184***	0.245***	0.147***	0.109***	0.058***	0.094***	0.085***	-0.039***	0.097***	0.160***
	(0.020)	(0.009)	(0.019)	(0.029)	(0.018)	(0.014)	(0.010)	(0.010)	(0.012)	(0.012)	(0.014)	(0.021)	(0.021)
Pedigree	0.155***	0.258***	0.321***	0.210***	0.426***	0.325***	0.327***	0.325***	0.299***	0.311***	0.293***	0.476***	0.319***
	(0.023)	(0.012)	(0.024)	(0.036)	(0.018)	(0.014)	(0.011)	(0.011)	(0.014)	(0.014)	(0.013)	(0.020)	(0.017)
Exhibition	0.423***	0.472***	0.419***	0.428***	0.417***	0.438***	0.474***	0.357***	0.382***	0.421***	0.257***	0.499***	0.348***
	(0.045)	(0.024)	(0.043)	(0.058)	(0.028)	(0.019)	(0.014)	(0.016)	(0.018)	(0.017)	(0.016)	(0.026)	(0.020)
Literature	0.495***	0.468***	0.534***	0.572***	0.355***	0.468***	0.272***	0.338***	0.431***	0.443***	0.524***	0.365***	0.492***
	(0.034)	(0.017)	(0.034)	(0.049)	(0.026)	(0.019)	(0.013)	(0.015)	(0.017)	(0.017)	(0.018)	(0.026)	(0.025)
Authentication	-0.280***	0.185***	0.355***	-0.143	0.524***	0.151***	0.182***	0.122***	0.078***	0.064**	-0.054*	0.034	0.353***
	(0.104)	(0.047)	(0.133)	(0.173)	(0.084)	(0.038)	(0.032)	(0.026)	(0.025)	(0.029)	(0.030)	(0.050)	(0.039)
Deceased						0.009	-0.590	0.189***	-0.024	-0.110***	0.037**	0.042*	0.379***
						(0.026)	(0.792)	(0.027)	(0.024)	(0.017)	(0.015)	(0.025)	(0.029)
Constant	8.094***	7.413***	7.735***	6.902***	6.345***	6.054***	6.540***	6.472***	6.586***	6.733***	6.175***	6.807***	6.743***
	(0.083)	(0.043)	(0.103)	(0.193)	(0.086)	(0.075)	(0.791)	(0.067)	(0.076)	(0.071)	(0.123)	(0.214)	(0.208)
Observations	32,967	134,530	32,438	14,760	48,954	72,356	114,066	89,162	61,340	62,315	49,471	27,058	31,004
R-squared	0.578	0.556	0.557	0.565	0.616	0.684	0.738	0.741	0.743	0.740	0.717	0.717	0.737
Artist FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Online Appendix 4 Hedonic Regressions by Art Movements since 1970 (5 Groups)

This table presents the hedonic regression results of movements since 1970. Eq. (1) is estimated using OLS. The dependent variable is the natural log of deflated hammer price. We run regressions on five groups of art movements: (1) Medieval & Renaissance, Baroque, Rococo; (2) Neoclassicism, Romanticism, Realism; and (3) Impressionism & Symbolism; (4) Fauvism & Expressionism, Cubism, Futurism & Constructivism, Dada & Surrealism; (5) Abstract Expressionism, Pop, Minimalism & Contemporary. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors are clustered at auction branch level and reported in parentheses.

Variables	(1) Medieval and Renaissance/Baroque/Rococo	(2) Neoclassicism/Romanticism /Realism	(3) Impressionism and Symbolism	(4) FE/CFC/DS	(5) Abstract Expressionism/Pop/Minimalism and Contemporary
Abstract	0.128	-0.216***	-0.186*	0.013	0.031**
	(0.120)	(0.055)	(0.113)	(0.012)	(0.013)
Animals	-0.077***	-0.051***	-0.095***	-0.068***	-0.001
	(0.012)	(0.015)	(0.018)	(0.013)	(0.021)
Landscape	-0.034***	0.000	0.010	-0.008	0.064***
	(0.010)	(0.011)	(0.012)	(0.010)	(0.017)
Seascape	-0.077***	0.046***	0.156***	0.159***	0.162***
	(0.018)	(0.015)	(0.014)	(0.014)	(0.028)
Urbanscape	0.043***	0.110***	0.120***	0.097***	0.087***
	(0.012)	(0.013)	(0.013)	(0.011)	(0.019)
Nude	-0.029	-0.270***	-0.155***	-0.073***	-0.041
	(0.035)	(0.018)	(0.020)	(0.012)	(0.027)
People	-0.037***	-0.034***	0.032***	0.064***	0.088***
	(0.008)	(0.011)	(0.012)	(0.009)	(0.018)
Self Portrait	0.256***	0.221***	0.201***	0.263***	0.529***
	(0.080)	(0.044)	(0.048)	(0.031)	(0.056)
Portrait	-0.133***	-0.189***	-0.241***	-0.114***	-0.000
	(0.013)	(0.015)	(0.018)	(0.013)	(0.026)
Religion	-0.100***	-0.122***	0.040*	0.028	0.015
	(0.010)	(0.024)	(0.021)	(0.019)	(0.033)
Still Life	0.130***	0.208***	0.064***	0.079***	0.131***
	(0.016)	(0.019)	(0.017)	(0.011)	(0.022)
Study	-0.057***	-0.201***	-0.320***	-0.136***	0.053**
	(0.020)	(0.017)	(0.018)	(0.017)	(0.024)

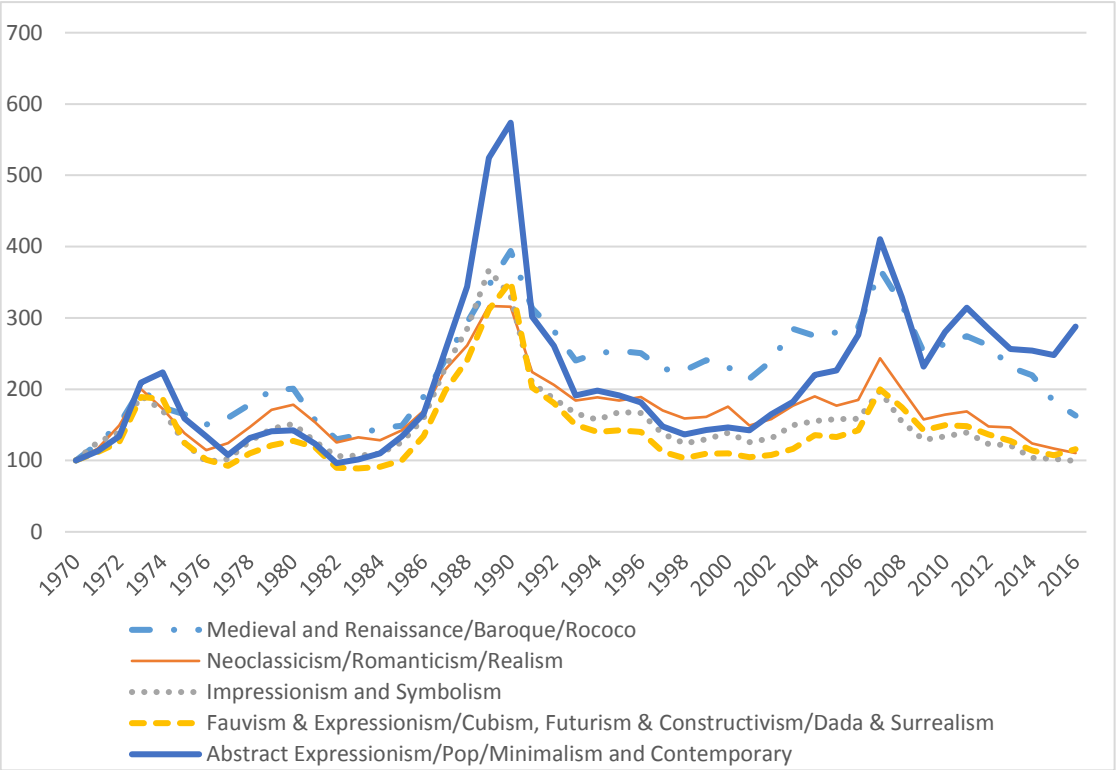
Variables	(1) Medieval and Renaissance/Baroque/Rococo	(2) Neoclassicism/Romanticism /Realism	(3) Impressionism and Symbolism	(4) FE/CFC/DS	(5) Abstract Expressionism/Pop/Minimalism and Contemporary
Other Topic	-0.060***	0.093***	0.092***	0.070***	0.131***
	(0.010)	(0.012)	(0.013)	(0.009)	(0.009)
Height	0.003***	0.011***	0.019***	0.013***	0.008***
	(0.000)	(0.001)	(0.002)	(0.001)	(0.000)
Width	0.007***	0.009***	0.017***	0.008***	0.005***
	(0.000)	(0.001)	(0.001)	(0.001)	(0.000)
Height_Sqr	-0.000**	-0.000***	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Width_Sqr	-0.000***	-0.000**	-0.000***	-0.000	-0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Oil	0.952***	1.226***	1.289***	1.497***	0.806***
	(0.011)	(0.011)	(0.012)	(0.009)	(0.009)
Watercolor	0.188***	0.595***	0.534***	0.642***	0.240***
	(0.021)	(0.011)	(0.011)	(0.006)	(0.010)
Signed	0.235***	0.238***	0.322***	0.267***	0.087***
	(0.009)	(0.008)	(0.009)	(0.006)	(0.010)
Dated	0.260***	0.257***	0.194***	0.137***	0.174***
	(0.011)	(0.008)	(0.008)	(0.006)	(0.008)
Inscribed	0.028***	0.005	-0.017*	-0.052***	-0.015*
	(0.009)	(0.009)	(0.010)	(0.007)	(0.008)
Attributed	-0.728***	-0.999***	-1.331***	-1.560***	-1.919***
	(0.007)	(0.014)	(0.032)	(0.054)	(0.163)
Studio	-0.707***	-1.075***	-1.438***	-1.383***	-1.348***
	(0.013)	(0.042)	(0.315)	(0.246)	(0.048)
Circle	-0.995***	-1.431***	-1.876***	-2.193***	
	(0.008)	(0.026)	(0.179)	(0.314)	
School	-1.266***	-1.799***	-2.576***	-2.527***	
	(0.013)	(0.040)	(0.181)	(0.401)	
After	-1.748***	-2.152***	-2.349***	-2.386***	-1.312***
	(0.013)	(0.036)	(0.180)	(0.188)	(0.419)
Style	-1.548***	-2.014***	-2.534***	-1.784***	-0.845
	(0.008)	(0.026)	(0.119)	(0.342)	(0.590)

Variables	(1) Medieval and Renaissance/Baroque/Rococo	(2) Neoclassicism/Romanticism /Realism	(3) Impressionism and Symbolism	(4) FE/CFC/DS	(5) Abstract Expressionism/Pop/Minimalism and Contemporary
Sotheby's London	0.511***	0.726***	0.649***	0.585***	0.731***
	(0.009)	(0.013)	(0.012)	(0.009)	(0.013)
Sotheby's New York	0.533***	0.765***	0.648***	0.558***	0.496***
	(0.011)	(0.011)	(0.012)	(0.009)	(0.012)
Sotheby's Other Branches	0.341***	0.300***	0.247***	0.260***	0.132***
	(0.010)	(0.017)	(0.019)	(0.014)	(0.017)
Christie's London	0.524***	0.729***	0.633***	0.625***	0.676***
	(0.009)	(0.014)	(0.014)	(0.010)	(0.015)
Christie's New York	0.376***	0.639***	0.562***	0.443***	0.373***
	(0.013)	(0.013)	(0.015)	(0.011)	(0.014)
Christie's Other Branches	0.104***	0.246***	0.238***	0.115***	0.128***
	(0.008)	(0.013)	(0.015)	(0.011)	(0.013)
Bonhams London	-0.219***	0.172***	0.185***	0.214***	0.300***
	(0.021)	(0.036)	(0.052)	(0.050)	(0.056)
Bonhams Other Branches	-0.061*	0.114***	0.067	-0.039	-0.193***
	(0.031)	(0.029)	(0.041)	(0.036)	(0.035)
Phillips London	0.009	0.221***	0.164***	0.143***	0.392***
	(0.014)	(0.029)	(0.046)	(0.038)	(0.036)
Phillips New York	-0.133**	0.383***	0.297***	0.332***	0.275***
	(0.059)	(0.047)	(0.052)	(0.053)	(0.028)
Auction_American	-0.296***	-0.038**	-0.034*	-0.223***	-0.302***
	(0.018)	(0.015)	(0.018)	(0.022)	(0.025)
Auction_European	0.274***	0.189***	0.109***	0.072***	0.032***
	(0.008)	(0.010)	(0.010)	(0.007)	(0.010)
Pedigree	0.258***	0.348***	0.327***	0.330***	0.376***
	(0.010)	(0.011)	(0.011)	(0.008)	(0.009)
Exhibition	0.460***	0.426***	0.474***	0.386***	0.342***

Variables	(1) Medieval and Renaissance/Baroque/Rococo	(2) Neoclassicism/Romanticism/Realism	(3) Impressionism and Symbolism	(4) FE/CFC/DS	(5) Abstract Expressionism/Pop/Minimalism and Contemporary
	(0.019)	(0.016)	(0.014)	(0.010)	(0.012)
Literature	0.498***	0.469***	0.272***	0.393***	0.480***
	(0.014)	(0.015)	(0.013)	(0.010)	(0.014)
Authentication	0.118***	0.192***	0.182***	0.107***	0.095***
	(0.042)	(0.035)	(0.032)	(0.016)	(0.022)
Deceased		-0.056**	-0.590	0.045***	0.089***
		(0.026)	(0.792)	(0.012)	(0.012)
Constant	7.573***	6.341***	6.540***	6.673***	6.512***
	(0.037)	(0.060)	(0.791)	(0.044)	(0.102)
Observations	192,312	131,982	114,066	189,988	105,995
R-squared	0.557	0.643	0.738	0.735	0.711
Artist FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES

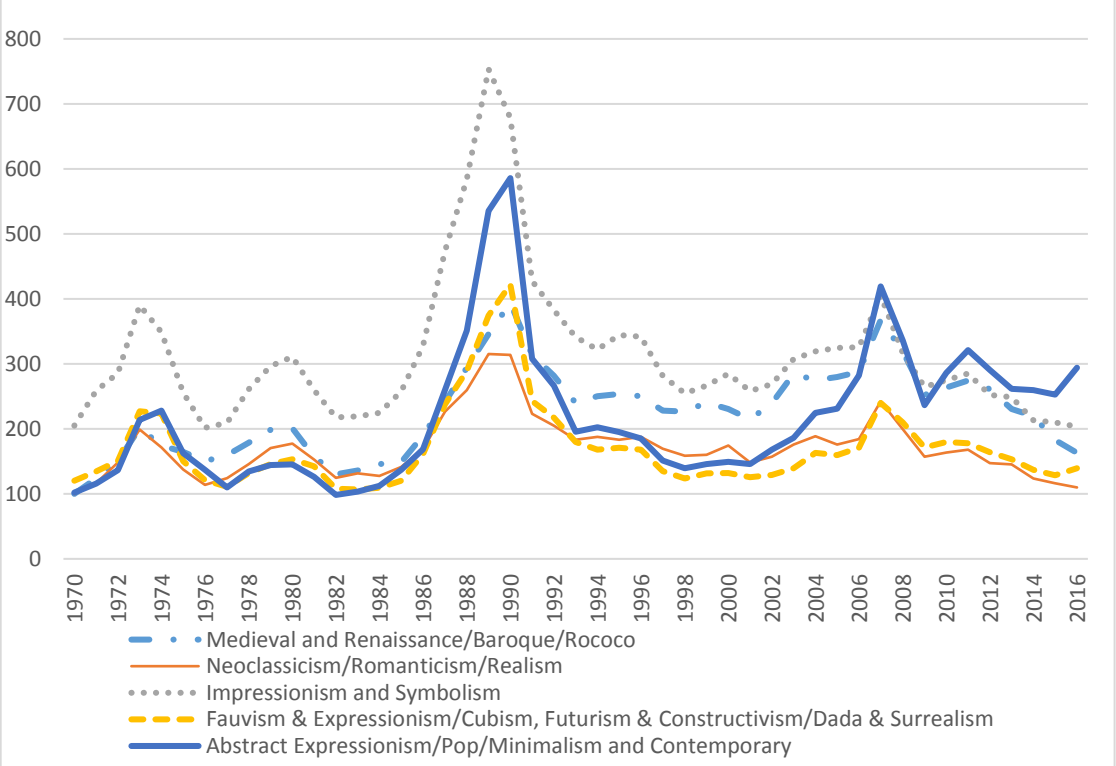
Online Appendix 5 Price Indices of Art Movements since 1970 (Indices Initial Values = 100)

This figure presents the art price indices of movements since 1970 detailed in Online Appendix 4. We classify artists into 5 groups: (1) Medieval & Renaissance, Baroque, Rococo; (2) Neoclassicism, Romanticism, Realism; and (3) Impressionism & Symbolism; (4) Fauvism & Expressionism, Cubism, Futurism & Constructivism, Dada & Surrealism; (5) Abstract Expressionism, Pop, Minimalism & Contemporary. The initial values of all indices are set to be 100 in year 1970.



Online Appendix 6 Price Indices of Art Movements since 1970 (Relative Initial Indices Values)

This figure presents the art price indices of movements since 1970 detailed in Online Appendix 4. We classify artists into 5 groups: (1) Medieval & Renaissance, Baroque, Rococo; (2) Neoclassicism, Romanticism, Realism; and (3) Impressionism & Symbolism; (4) Fauvism & Expressionism, Cubism, Futurism & Constructivism, Dada & Surrealism; (5) Abstract Expressionism, Pop, Minimalism & Contemporary. The initial index value of Medieval & Renaissance, Baroque, Rococo group is set to be 100 in year 1970. The initial indices values of other art movements groups are normalized by the average price of the period from 1966 to 1970 relative to the Medieval & Renaissance, Baroque, Rococo group's.



Online Appendix 7 Hedonic Regressions of Art Movements and Topics

This table presents the hedonic regression results including the interactions of movements and topics and excluding artist control variables. Eq. (1) is estimated using OLS. The dependent variable is the natural log of deflated hammer price. Table 9 includes thirteen movements (Medieval & Renaissance; Baroque; Rococo; Neoclassicism; Romanticism; Realism; Impressionism & Symbolism; Fauvism & Expressionism; Cubism, Futurism & Constructivism; Dada & Surrealism; Abstract Expressionism; Pop; Minimalism & Contemporary) and twelve topics (Abstract; Animals; Landscape; Seascape; Urbanscape; Nude; People; self-Portrait; Portrait; Religion; still life; Study). *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors are clustered at auction branch level and reported in parentheses.

Variables	(1)
Medieval_Renaissance	0.624***
	(0.012)
Baroque	0.251***
	(0.006)
Rococo	0.548***
	(0.010)
Neoclassicism	0.159***
	(0.014)
Romanticism	0.213***
	(0.009)
Realism	0.072***
	(0.008)
Impressionism_Symbolism	0.505***
	(0.007)
Fauvism_Expressionism	0.681***
	(0.007)
Cubism_Futurism_Constructivism	0.576***
	(0.008)
Dada_Surrealism	0.536***
	(0.008)
Abstract_Expressionism	0.396***
	(0.007)
Pop	0.656***
	(0.010)
Minimalism_Contemporary	0.411***
	(0.009)
Abstract	-0.100***
	(0.008)
Animals	-0.056***
	(0.007)
Landscape	-0.026***
	(0.004)
Seascape	-0.151***
	(0.007)
Urbanscape	0.039***
	(0.005)
Nude	-0.234***
	(0.010)
People	-0.053***
	(0.005)
Self Portrait	-0.049**
	(0.021)
Portrait	-0.333***
	(0.006)

Religion	0.030***
	(0.011)
Still Life	0.232***
	(0.007)
Study	-0.293***
	(0.010)
Medieval_Renaissance_Abstract	0.294
	(0.298)
Medieval_Renaissance_Animals	0.202***
	(0.061)
Medieval_Renaissance_Landscape	0.290***
	(0.030)
Medieval_Renaissance_Seascape	-0.144
	(0.121)
Medieval_Renaissance_Urbanscape	0.143***
	(0.040)
Medieval_Renaissance_Nude	0.310***
	(0.072)
Medieval_Renaissance_People	0.120***
	(0.016)
Medieval_Renaissance_Self Portrait	0.692**
	(0.308)
Medieval_Renaissance_Portrait	0.293***
	(0.023)
Medieval_Renaissance_Religion	0.026
	(0.019)
Medieval_Renaissance_Still Life	-0.215***
	(0.071)
Medieval_Renaissance_Study	0.327***
	(0.045)
Baroque_Abstract	0.367**
	(0.162)
Baroque_Animals	-0.122***
	(0.014)
Baroque_Landscape	0.166***
	(0.009)
Baroque_Seascape	0.370***
	(0.018)
Baroque_Urbanscape	0.217***
	(0.014)
Baroque_Nude	0.140**
	(0.055)
Baroque_People	0.056***
	(0.010)
Baroque_Self Portrait	0.373***
	(0.104)
Baroque_Portrait	-0.116***
	(0.012)
Baroque_Religion	-0.177***
	(0.014)
Baroque_Still Life	0.387***
	(0.014)
Baroque_Study	0.377***
	(0.027)
Rococo_Abstract	0.349
	(0.348)
Rococo_Animals	0.043
	(0.035)
Rococo_Landscape	-0.103***
	(0.020)

Rococo_Seascape	0.215***
	(0.067)
Rococo_Urbanscape	0.547***
	(0.028)
Rococo_Nude	0.136*
	(0.077)
Rococo_People	0.038**
	(0.017)
Rococo_Self Portrait	-0.062
	(0.157)
Rococo_Portrait	-0.180***
	(0.019)
Rococo_Religion	-0.213***
	(0.024)
Rococo_Still Life	-0.320***
	(0.045)
Rococo_Study	0.166***
	(0.042)
Neoclassicism_Abstract	-0.143
	(0.238)
Neoclassicism_Animals	-0.003
	(0.078)
Neoclassicism_Landscape	-0.009
	(0.039)
Neoclassicism_Seascape	0.363***
	(0.107)
Neoclassicism_Urbanscape	0.165***
	(0.050)
Neoclassicism_Nude	0.013
	(0.090)
Neoclassicism_People	-0.113***
	(0.026)
Neoclassicism_Self Portrait	0.273***
	(0.100)
Neoclassicism_Portrait	0.348***
	(0.028)
Neoclassicism_Religion	-0.209***
	(0.046)
Neoclassicism_Still Life	-0.233**
	(0.091)
Neoclassicism_Study	0.150***
	(0.051)
Romanticism_Abstract	0.223
	(0.262)
Romanticism_Animals	-0.034
	(0.023)
Romanticism_Landscape	-0.045***
	(0.013)
Romanticism_Seascape	0.278***
	(0.024)
Romanticism_Urbanscape	0.086***
	(0.022)
Romanticism_Nude	-0.442***
	(0.053)
Romanticism_People	-0.153***
	(0.020)
Romanticism_Self Portrait	-0.003
	(0.159)
Romanticism_Portrait	0.020
	(0.023)

Romanticism_Religion	-0.167***
	(0.049)
Romanticism_Still Life	-0.249***
	(0.048)
Romanticism_Study	0.220***
	(0.032)
Realism_Abstract	0.132**
	(0.059)
Realism_Animals	-0.064**
	(0.026)
Realism_Landscape	0.153***
	(0.015)
Realism_Seascape	-0.051**
	(0.023)
Realism_Urbanscape	0.054***
	(0.018)
Realism_Nude	-0.352***
	(0.027)
Realism_People	-0.041***
	(0.015)
Realism_Self Portrait	-0.125*
	(0.071)
Realism_Portrait	0.096***
	(0.024)
Realism_Religion	-0.179***
	(0.043)
Realism_Still Life	0.161***
	(0.025)
Realism_Study	0.081***
	(0.025)
Impressionism_Symbolism_Abstract	-0.449***
	(0.116)
Impressionism_Symbolism_Animals	-0.170***
	(0.023)
Impressionism_Symbolism_Landscape	-0.071***
	(0.012)
Impressionism_Symbolism_Seascape	0.322***
	(0.017)
Impressionism_Symbolism_Urbanscape	-0.045***
	(0.015)
Impressionism_Symbolism_Nude	0.097***
	(0.024)
Impressionism_Symbolism_People	0.148***
	(0.014)
Impressionism_Symbolism_Self Portrait	-0.171**
	(0.068)
Impressionism_Symbolism_Portrait	0.030
	(0.023)
Impressionism_Symbolism_Religion	0.138***
	(0.031)
Impressionism_Symbolism_Still Life	-0.032
	(0.023)
Impressionism_Symbolism_Study	0.026
	(0.023)
Fauvism_Expressionism_Abstract	-0.091**
	(0.046)
Fauvism_Expressionism_Animals	0.069***
	(0.025)
Fauvism_Expressionism_Landscape	0.053***
	(0.013)

Fauvism_Expressionism_Seascape	0.338***
	(0.020)
Fauvism_Expressionism_Urbanscape	0.126***
	(0.016)
Fauvism_Expressionism_Nude	-0.110***
	(0.020)
Fauvism_Expressionism_People	-0.023
	(0.015)
Fauvism_Expressionism_Self Portrait	0.307***
	(0.067)
Fauvism_Expressionism_Portrait	0.301***
	(0.027)
Fauvism_Expressionism_Religion	-0.074**
	(0.035)
Fauvism_Expressionism_Still Life	-0.214***
	(0.016)
Fauvism_Expressionism_Study	-0.050
	(0.034)
Cubism_Futurism_Constructivism_Abstract	0.086***
	(0.019)
Cubism_Futurism_Constructivism_Animals	-0.013
	(0.032)
Cubism_Futurism_Constructivism_Landscape	-0.243***
	(0.019)
Cubism_Futurism_Constructivism_Seascape	-0.145***
	(0.030)
Cubism_Futurism_Constructivism_Urbanscape	-0.103***
	(0.024)
Cubism_Futurism_Constructivism_Nude	0.042
	(0.031)
Cubism_Futurism_Constructivism_People	0.131***
	(0.019)
Cubism_Futurism_Constructivism_Self Portrait	0.097
	(0.088)
Cubism_Futurism_Constructivism_Portrait	-0.202***
	(0.033)
Cubism_Futurism_Constructivism_Religion	0.175***
	(0.061)
Cubism_Futurism_Constructivism_Still Life	0.260***
	(0.021)
Cubism_Futurism_Constructivism_Study	0.048
	(0.033)
Dada_Surrealism_Abstract	-0.457***
	(0.019)
Dada_Surrealism_Animals	0.399***
	(0.026)
Dada_Surrealism_Landscape	-0.211***
	(0.028)
Dada_Surrealism_Seascape	0.312***
	(0.052)
Dada_Surrealism_Urbanscape	-0.283***
	(0.033)
Dada_Surrealism_Nude	0.168***
	(0.030)
Dada_Surrealism_People	0.307***
	(0.017)
Dada_Surrealism_Self Portrait	0.158**
	(0.067)
Dada_Surrealism_Portrait	0.276***
	(0.028)

Dada_Surrealism_Religion	-0.036
	(0.049)
Dada_Surrealism_Still Life	-0.145***
	(0.028)
Dada_Surrealism_Study	-0.111***
	(0.036)
Abstract_Expressionism_Abstract	0.286***
	(0.016)
Abstract_Expressionism_Animals	-0.182***
	(0.029)
Abstract_Expressionism_Landscape	-0.235***
	(0.029)
Abstract_Expressionism_Seascape	0.257***
	(0.048)
Abstract_Expressionism_Urbanscape	-0.104**
	(0.042)
Abstract_Expressionism_Nude	-0.328***
	(0.043)
Abstract_Expressionism_People	0.107***
	(0.034)
Abstract_Expressionism_Self Portrait	-0.384***
	(0.102)
Abstract_Expressionism_Portrait	-0.076
	(0.049)
Abstract_Expressionism_Religion	-0.238***
	(0.067)
Abstract_Expressionism_Still Life	-0.305***
	(0.041)
Abstract_Expressionism_Study	0.322***
	(0.062)
Pop_Abstract	-0.258***
	(0.062)
Pop_Animals	-0.067
	(0.057)
Pop_Landscape	0.235***
	(0.037)
Pop_Seascape	0.373***
	(0.058)
Pop_Urbanscape	0.153***
	(0.040)
Pop_Nude	0.416***
	(0.040)
Pop_People	0.172***
	(0.043)
Pop_Self Portrait	1.104***
	(0.128)
Pop_Portrait	0.295***
	(0.049)
Pop_Religion	-0.287***
	(0.080)
Pop_Still Life	0.222***
	(0.045)
Pop_Study	0.368***
	(0.040)
Minimalism_Contemporary_Abstract	-0.235***
	(0.045)
Minimalism_Contemporary_Animals	0.179***
	(0.066)
Minimalism_Contemporary_Landscape	0.764***
	(0.054)

Minimalism_Contemporary_Seascape	0.477***
	(0.097)
Minimalism_Contemporary_Urbanscape	0.156***
	(0.048)
Minimalism_Contemporary_Nude	-0.021
	(0.066)
Minimalism_Contemporary_People	0.059
	(0.040)
Minimalism_Contemporary_Self Portrait	0.495***
	(0.091)
Minimalism_Contemporary_Portrait	0.519***
	(0.067)
Minimalism_Contemporary_Religion	-0.116*
	(0.063)
Minimalism_Contemporary_Still Life	-0.290***
	(0.057)
Minimalism_Contemporary_Study	0.093*
Other Artist Characteristics	YES
Other Artwork Characteristics	YES
Provenance Characteristics	YES
Transaction Characteristics	YES
Constant	5.820***
	(0.039)
Observations	1,372,188
R-squared	0.419

Online Appendix 8 Hedonic Regressions by Art Movements: Artist Nationalities

This table presents the hedonic regression results of movements including artist nationality variables. Eq. (1) is estimated using OLS. The dependent variable is the natural log of deflated hammer price. This table includes the artist nationality variables (British; Dutch and Belgian; French; German; Italian; Spanish; Russian; American) and exclude the artist control variables. We run regressions on thirteen subsamples of movements: (1) Medieval & Renaissance; (2) Baroque; and (3) Rococo; (4) Neoclassicism; (5) Romanticism; (6) Realism; (7) Impressionism & Symbolism; (8) Fauvism & Expressionism; (9) Cubism, Futurism & Constructivism; (10) Dada & Surrealism; (11) Abstract Expressionism; (12) Pop; (13) Minimalism & Contemporary. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors are clustered at auction branch level and reported in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Variables	Medieval and Renaissance	Baroque	Rococo	Neoclassicism	Romanticism	Realism	Impressionism and Symbolism	Fauvism and Expressionism	Cubism Futurism and Constructivism	Dada and Surrealism	Abstract Expressionism	Pop	Minimalism and Contemporary
British	0.210	-0.256***	-0.058*	-0.225***	-0.101***	-0.746***	-0.833***	-0.772***	0.398***	-0.106***	-0.849	-0.257***	-0.329***
	(0.297)	(0.020)	(0.034)	(0.039)	(0.021)	(0.020)	(0.021)	(0.041)	(0.038)	(0.026)	(0.000)	(0.044)	(0.029)
Dutch_Belgian	-0.008	0.312***	-0.491***	-0.545***	0.173***	-0.650***	-0.150***	-0.209***	0.019	0.765***	0.148	-0.579**	-0.394***
	(0.038)	(0.016)	(0.045)	(0.057)	(0.024)	(0.022)	(0.017)	(0.020)	(0.045)	(0.025)	(0.000)	(0.291)	(0.073)
French	0.171***	0.268***	0.416***	0.347***	0.265***	0.355***	0.278***	-0.234***	0.389***	0.269***	0.103	0.732***	0.004
	(0.054)	(0.017)	(0.029)	(0.029)	(0.018)	(0.016)	(0.012)	(0.014)	(0.015)	(0.014)	(0.000)	(0.038)	(0.045)
German	0.137***	-0.181***	-0.173***	-0.014	0.056**	0.322***	-0.021	0.343***	0.860***	0.443***	0.070	0.616***	-0.317***
	(0.047)	(0.019)	(0.041)	(0.037)	(0.023)	(0.017)	(0.022)	(0.014)	(0.029)	(0.018)	(0.000)	(0.036)	(0.024)
Italian	-0.159***	0.195***	0.596***	0.402***	0.068	0.068***	-0.108***	0.220***	0.503***	1.061***	0.759	0.103***	-0.364***
	(0.037)	(0.016)	(0.030)	(0.035)	(0.049)	(0.024)	(0.034)	(0.024)	(0.020)	(0.027)	(0.000)	(0.035)	(0.026)
Spanish	0.064	0.325***	1.189***	-0.022	0.668***	0.618***	0.313***	0.487***	2.055***	1.416***	0.439		
	(0.067)	(0.025)	(0.094)	(0.135)	(0.083)	(0.042)	(0.039)	(0.141)	(0.022)	(0.016)	(0.000)		
Russian		0.390	0.970*	0.612***	0.954***	-0.147***	-0.579***	0.738***	0.339***	-0.332***	-1.102		-0.155
		(0.444)	(0.555)	(0.199)	(0.041)	(0.043)	(0.027)	(0.023)	(0.016)	(0.019)	(0.000)		(0.116)
American			-0.693***	-0.055	0.060***	-0.295***	-0.515***	-0.542***	-0.363***	-0.279***	-0.173	0.629***	-0.213***
			(0.236)	(0.053)	(0.021)	(0.016)	(0.017)	(0.017)	(0.028)	(0.020)	(0.000)	(0.034)	(0.023)
Artist FE	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Other Artist Characteristics	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Artwork Characteristics	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Provenance Characteristics	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Transaction Characteristics	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Constant	8.521***	6.719***	7.179***	5.683***	6.003***	5.579***	4.449***	4.958***	5.306***	4.735***	6.305	5.505***	5.869***
	(0.165)	(0.078)	(0.131)	(0.191)	(0.157)	(0.145)	(0.988)	(0.160)	(0.306)	(0.191)	(0.000)	(0.169)	(0.114)
Observations	35,103	141,204	34,575	15,165	50,434	73,762	117,077	90,839	62,254	63,156	49,651	27,106	31,023
R-squared	0.433	0.445	0.461	0.451	0.409	0.472	0.501	0.538	0.574	0.596	0.537	0.592	0.548

Online Appendix 9 Hedonic Regressions of Art Movements and Artist Nationalities

This table presents the hedonic regression results including the interactions of movements and artist nationality and excluding artist control variables. This table includes thirteen movements (Medieval & Renaissance; Baroque; Rococo; Neoclassicism; Romanticism; Realism; Impressionism & Symbolism; Fauvism & Expressionism; Cubism, Futurism & Constructivism; Dada & Surrealism; Abstract Expressionism; Pop; Minimalism & Contemporary) and nine nationalities (British; Dutch & Belgian; French; German; Italian; Spanish; Russian; American). The dependent variable is the natural log of deflated hammer price. This table includes the artist nationality variables and exclude the artist control variables. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors are clustered at auction branch level and reported in parentheses.

Variables	(1)
American	-0.180***
	(0.007)
British	-0.702***
	(0.005)
Dutch_Belgian	-0.410***
	(0.006)
French	-0.240***
	(0.005)
German	-0.208***
	(0.006)
Italian	-0.023***
	(0.006)
Spanish	-0.040***
	(0.010)
Russian	0.043***
	(0.009)
Medieval_Renaissance	0.605***
	(0.038)
Baroque	-0.231***
	(0.017)
Rococo	0.141***
	(0.027)
Neoclassicism	-0.174***
	(0.024)
Romanticism	-0.197***
	(0.013)
Realism	0.221***
	(0.014)
Impressionism_Symbolism	0.139***
	(0.011)
Fauvism_Expressionism	0.554***
	(0.011)
Cubism_Futurism_Constructivism	-0.140***
	(0.015)
Dada_Surrealism	0.074***
	(0.011)
Abstract_Expressionism	0.237***
	(0.015)
Pop	-0.183***
	(0.028)
Minimalism_Contemporary	0.525***
	(0.020)
Medieval_Renaissance_British	0.636
	(0.462)
Medieval_Renaissance_Dutch_Belgian	0.381***

	(0.039)
Medieval_Renaissance_French	0.489***
	(0.056)
Medieval_Renaissance_German	0.516***
	(0.048)
Medieval_Renaissance_Italian	-0.196***
	(0.039)
Medieval_Renaissance_Spanish	0.003
	(0.072)
Baroque_British	0.217***
	(0.022)
Baroque_Dutch_Belgian	0.813***
	(0.017)
Baroque_French	0.509***
	(0.018)
Baroque_German	0.131***
	(0.021)
Baroque_Italian	0.134***
	(0.018)
Baroque_Spanish	0.316***
	(0.029)
Baroque_Russian	0.777
	(0.478)
Rococo_American	-0.369
	(0.249)
Rococo_British	0.169***
	(0.033)
Rococo_Dutch_Belgian	-0.374***
	(0.047)
Rococo_French	0.429***
	(0.029)
Rococo_German	-0.017
	(0.041)
Rococo_Italian	0.438***
	(0.030)
Rococo_Spanish	1.063***
	(0.111)
Rococo_Russian	0.145
	(0.531)
Neoclassicism_American	0.258***
	(0.053)
Neoclassicism_British	0.232***
	(0.038)
Neoclassicism_Dutch_Belgian	-0.161***
	(0.052)
Neoclassicism_French	0.512***
	(0.029)
Neoclassicism_German	0.253***
	(0.038)
Neoclassicism_Italian	0.303***
	(0.034)
Neoclassicism_Spanish	0.058
	(0.130)
Neoclassicism_Russian	-0.268
	(0.195)
Romanticism_American	0.314***
	(0.018)
Romanticism_British	0.704***
	(0.018)
Romanticism_Dutch_Belgian	0.635***

	(0.024)
Romanticism_French	0.426***
	(0.017)
Romanticism_German	0.237***
	(0.023)
Romanticism_Italian	0.080
	(0.049)
Romanticism_Spanish	0.033
	(0.081)
Romanticism_Russian	0.997***
	(0.039)
Realism_American	-0.260***
	(0.019)
Realism_British	-0.166***
	(0.019)
Realism_Dutch_Belgian	-0.532***
	(0.023)
Realism_French	0.262***
	(0.017)
Realism_German	-0.105***
	(0.020)
Realism_Italian	-0.575***
	(0.031)
Realism_Spanish	0.170***
	(0.053)
Realism_Russian	-0.299***
	(0.043)
Impressionism_Symbolism_American	-0.088***
	(0.016)
Impressionism_Symbolism_British	0.132***
	(0.020)
Impressionism_Symbolism_Dutch_Belgian	0.246***
	(0.018)
Impressionism_Symbolism_French	0.702***
	(0.013)
Impressionism_Symbolism_German	0.121***
	(0.023)
Impressionism_Symbolism_Italian	0.007
	(0.035)
Impressionism_Symbolism_Spanish	0.310***
	(0.048)
Impressionism_Symbolism_Russian	-0.560***
	(0.026)
Fauvism_Expressionism_American	-0.377***
	(0.023)
Fauvism_Expressionism_British	0.033
	(0.042)
Fauvism_Expressionism_Dutch_Belgian	0.207***
	(0.022)
Fauvism_Expressionism_French	-0.018
	(0.013)
Fauvism_Expressionism_German	0.547***
	(0.015)
Fauvism_Expressionism_Italian	0.441***
	(0.029)
Fauvism_Expressionism_Spanish	0.796***
	(0.125)
Fauvism_Expressionism_Russian	0.591***
	(0.029)
Cubism_Futurism_Constructivism_American	-0.224***

	(0.028)
Cubism_Futurism_Constructivism_British	1.258***
	(0.037)
Cubism_Futurism_Constructivism_Dutch_Belgian	0.454***
	(0.043)
Cubism_Futurism_Constructivism_French	0.680***
	(0.017)
Cubism_Futurism_Constructivism_German	0.423***
	(0.030)
Cubism_Futurism_Constructivism_Italian	0.610***
	(0.021)
Cubism_Futurism_Constructivism_Spanish	1.152***
	(0.026)
Cubism_Futurism_Constructivism_Russian	0.381***
	(0.019)
Dada_Surrealism_American	-0.207***
	(0.024)
Dada_Surrealism_British	0.582***
	(0.026)
Dada_Surrealism_Dutch_Belgian	1.100***
	(0.027)
Dada_Surrealism_French	0.291***
	(0.015)
Dada_Surrealism_German	0.379***
	(0.022)
Dada_Surrealism_Italian	1.100***
	(0.028)
Dada_Surrealism_Spanish	1.040***
	(0.020)
Dada_Surrealism_Russian	-0.635***
	(0.021)
Abstract_Expressionism_American	-0.019
	(0.018)
Abstract_Expressionism_British	-0.198***
	(0.023)
Abstract_Expressionism_Dutch_Belgian	0.629***
	(0.019)
Abstract_Expressionism_French	0.421***
	(0.016)
Abstract_Expressionism_German	0.301***
	(0.020)
Abstract_Expressionism_Italian	0.918***
	(0.032)
Abstract_Expressionism_Spanish	-0.265***
	(0.037)
Abstract_Expressionism_Russian	-1.235***
	(0.046)
Pop_American	1.113***
	(0.031)
Pop_British	0.779***
	(0.041)
Pop_Dutch_Belgian	-0.015
	(0.220)
Pop_French	1.156***
	(0.034)
Pop_German	0.916***
	(0.040)
Pop_Italian	0.215***
	(0.034)
Minimalism_Contemporary_American	-0.151***

	(0.024)
Minimalism_Contemporary_British	0.536***
	(0.030)
Minimalism_Contemporary_Dutch_Belgian	0.198***
	(0.074)
Minimalism_Contemporary_French	0.038
	(0.043)
Minimalism_Contemporary_German	-0.125***
	(0.026)
Minimalism_Contemporary_Italian	-0.397***
	(0.027)
Minimalism_Contemporary_Russian	-0.069
	(0.113)
Other Artist Characteristics	NO
Artwork Characteristics	YES
Provenance Characteristics	YES
Transaction Characteristics	YES
Constant	5.910***
	(0.039)
Observations	1,372,188
R-squared	0.446

Online Appendix 10 Hedonic Regressions by Art Markets since 1970

This table presents the hedonic regression results of auction markets since 1970 including three categories: UK, USA, European continent. The dependent variable is the natural log of deflated hammer price. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors are clustered at auction branch level and reported in parentheses.

Variables	(1) UK	(2) USA	(3) European Continent
Abstract	-0.0418***	-0.0303*	-0.0122**
	(0.0148)	(0.0173)	(0.0055)
Animals	-0.0588***	-0.0352***	-0.0271***
	(0.0071)	(0.0086)	(0.0051)
Landscape	-0.0487***	0.0025	-0.0004
	(0.0056)	(0.0064)	(0.0038)
Seascape	0.0146*	0.0592***	0.0840***
	(0.0075)	(0.0089)	(0.0052)
Urbanscape	0.0825***	0.1249***	0.1236***
	(0.0059)	(0.0071)	(0.0042)
Nude	-0.0921***	-0.1089***	-0.0828***
	(0.0126)	(0.0131)	(0.0073)
People	-0.0159***	0.0039	0.0221***
	(0.0057)	(0.0068)	(0.0040)
Self Portrait	0.2444***	0.2282***	0.1183***
	(0.0289)	(0.0318)	(0.0152)
Portrait	-0.1521***	-0.1986***	-0.1638***
	(0.0090)	(0.0106)	(0.0061)
Religion	-0.0751***	0.0326***	-0.0027
	(0.0098)	(0.0124)	(0.0069)
Still Life	0.0927***	0.0702***	0.0719***
	(0.0083)	(0.0088)	(0.0050)
Study	-0.1894***	-0.1528***	-0.1964***
	(0.0107)	(0.0136)	(0.0086)
Other Topic	0.0343***	0.1086***	0.0616***
	(0.0056)	(0.0059)	(0.0035)
Height	0.0053***	0.0062***	0.0061***
	(0.0002)	(0.0002)	(0.0002)
Width	0.0056***	0.0049***	0.0064***
	(0.0002)	(0.0002)	(0.0002)
Height_Sqr	-0.0001***	-0.0001***	-0.0001***
	(0.0000)	(0.0000)	(0.0000)
Width_Sqr	-0.0001***	-0.0001***	-0.0001***
	(0.0000)	(0.0000)	(0.0000)
Oil	1.1427***	1.2258***	1.2174***
	(0.0082)	(0.0080)	(0.0063)
Watercolor	0.4210***	0.4400***	0.4664***
	(0.0061)	(0.0072)	(0.0038)
Signed	0.2165***	0.1744***	0.2140***
	(0.0045)	(0.0056)	(0.0032)
Dated	0.1525***	0.1637***	0.1525***
	(0.0042)	(0.0046)	(0.0026)
Inscribed	-0.0158***	-0.0331***	0.0351***
	(0.0041)	(0.0050)	(0.0032)
Attributed	-0.5895***	-0.9994***	-0.6757***
	(0.0084)	(0.0105)	(0.0057)
Studio	-0.7089***	-1.1211***	-0.7370***
	(0.0199)	(0.0362)	(0.0179)
Circle	-0.8487***	-1.3579***	-0.9615***
	(0.0092)	(0.0170)	(0.0106)
School	-0.8793***	-1.7446***	-1.2959***
	(0.0644)	(0.0189)	(0.0168)
After	-1.6097***	-2.1146***	-1.5877***
	(0.0168)	(0.0293)	(0.0188)
Style	-1.3451***	-1.9962***	-1.4263***
	(0.0093)	(0.0209)	(0.0111)

Variables	(1) UK	(2) USA	(3) European Continent
Deceased	0.1959***	0.2098***	0.0999***
	(0.0115)	(0.0110)	(0.0061)
Sotheby's London	0.9427***		
	(0.0065)		
Sotheby's New York		0.8735***	
		(0.0066)	
Sotheby's Other Branches	0.2874***	0.0085	0.3508***
	(0.0129)	(0.0867)	(0.0050)
Christie's London	0.9766***		
	(0.0068)		
Christie's New York		0.7100***	
		(0.0068)	
Christie's Other Branches	0.1945***	0.7707***	0.2411***
	(0.0060)	(0.0128)	(0.0049)
Bonhams London	0.4749***		
	(0.0089)		
Bonhams Other Branches	-0.0010	0.0591***	0.5407***
	(0.0066)	(0.0104)	(0.0246)
Phillips London	0.5305***		
	(0.0088)		
Phillips New York		0.5529***	
		(0.0145)	
Pedigree	0.2309***	0.2375***	0.3000***
	(0.0051)	(0.0055)	(0.0042)
Exhibition	0.3488***	0.3930***	0.3601***
	(0.0075)	(0.0085)	(0.0068)
Literature	0.3790***	0.4219***	0.3892***
	(0.0083)	(0.0090)	(0.0062)
Authentication	0.1452***	0.1302***	0.1722***
	(0.0271)	(0.0217)	(0.0059)
Constant	5.6325***	6.4670***	6.2733***
	(0.0242)	(0.0638)	(0.0308)
Observations	460,911	412,159	986,010
R-squared	0.7525	0.7886	0.7066
Artist FE	YES	YES	YES
Year FE	YES	YES	YES
Month FE	YES	YES	YES

Online Appendix 11 Hedonic Regressions by Auction House Size since 1970

This table presents the hedonic regression results by auction house size since 1970, namely five subsamples dividing the market into top, large, medium, and small segmentations. They are (1) Sotheby's and Christie's (SC); (2) Bonhams and Phillips (BP); and (3) Important European Auction Houses (European); (4) Important American Auction Houses (American); (5) Other Small Auction Houses (Small). The dependent variable is the natural log of deflated hammer price. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors are clustered at auction branch level and reported in parentheses.

Variables	(1) SC	(2) BP	(3) American	(4) European	(5) Small
Abstract	0.0006	-0.0210	-0.0124	-0.0569**	0.0147
	(0.0267)	(0.0449)	(0.0199)	(0.0243)	(0.0377)
Animals	-0.0622***	-0.0438***	-0.0179	-0.0190**	0.0354
	(0.0087)	(0.0156)	(0.0281)	(0.0080)	(0.0386)
Landscape	-0.0075	-0.0145	-0.0227	0.0067	0.0723
	(0.0172)	(0.0142)	(0.0265)	(0.0104)	(0.0576)
Seascape	0.0495***	0.0342**	0.0567*	0.0639***	0.1221***
	(0.0153)	(0.0130)	(0.0263)	(0.0209)	(0.0375)
Urbanscape	0.1151***	0.0789***	0.1055***	0.1223***	0.1486***
	(0.0116)	(0.0118)	(0.0233)	(0.0124)	(0.0331)
Nude	-0.1193***	-0.0962***	-0.0870**	-0.1138**	-0.0259
	(0.0144)	(0.0234)	(0.0299)	(0.0493)	(0.0396)
People	0.0058	0.0015	-0.0300	0.0180	0.0531
	(0.0104)	(0.0145)	(0.0190)	(0.0170)	(0.0334)
Self Portrait	0.2356***	0.3142***	0.0955	0.0318	0.1886***
	(0.0359)	(0.0493)	(0.1049)	(0.0502)	(0.0464)
Portrait	-0.1675***	-0.1498***	-0.2240***	-0.1566***	-0.1346***
	(0.0117)	(0.0202)	(0.0409)	(0.0216)	(0.0303)
Religion	-0.0497**	-0.0127	0.0450	-0.0335	0.0801**
	(0.0224)	(0.0235)	(0.0463)	(0.0239)	(0.0359)
Still Life	0.1104***	0.0751***	-0.0165	0.1044***	0.0998**
	(0.0141)	(0.0270)	(0.0376)	(0.0185)	(0.0476)
Study	-0.1695***	-0.1708***	-0.1099***	-0.2628***	-0.1314***
	(0.0147)	(0.0257)	(0.0342)	(0.0288)	(0.0284)
Other Topic	0.0699***	0.0648***	0.0678*	0.0240*	0.1422***
	(0.0167)	(0.0138)	(0.0325)	(0.0138)	(0.0507)
Height	0.0084***	0.0059***	0.0045*	0.0064***	0.0065***
	(0.0006)	(0.0003)	(0.0022)	(0.0003)	(0.0002)
Width	0.0052***	0.0051***	0.0035**	0.0059***	0.0058***
	(0.0002)	(0.0003)	(0.0012)	(0.0003)	(0.0003)
Height_Sqr	-0.0001***	-0.0001***	-0.0001*	-0.0001***	-0.0001***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Width_Sqr	-0.0001***	-0.0001***	-0.0001	-0.0001***	-0.0001***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Oil	1.1696***	1.0593***	1.2489***	1.2535***	1.1924***
	(0.0225)	(0.0332)	(0.0737)	(0.0408)	(0.0211)
Watercolor	0.4360***	0.3712***	0.4777***	0.4552***	0.4388***
	(0.0208)	(0.0359)	(0.0303)	(0.0516)	(0.0219)
Signed	0.2414***	0.1685***	0.1847***	0.2339***	0.1591***
	(0.0150)	(0.0120)	(0.0121)	(0.0170)	(0.0254)
Dated	0.1622***	0.1256***	0.1546***	0.1479***	0.1694***
	(0.0048)	(0.0127)	(0.0259)	(0.0100)	(0.0135)
Inscribed	-0.0301***	-0.0007	0.0161	0.0357***	0.0455***
	(0.0097)	(0.0148)	(0.0111)	(0.0129)	(0.0112)
Attributed	-0.7150***	-0.5573***	-0.7700***	-0.6613***	-0.7776***

Variables	(1) SC	(2) BP	(3) American	(4) European	(5) Small
	(0.0518)	(0.0536)	(0.0538)	(0.0264)	(0.0300)
Studio	-0.9248***	-0.3433***	-0.5601***	-0.7388***	-0.6415***
	(0.0800)	(0.1032)	(0.1419)	(0.0870)	(0.0499)
Circle	-1.0582***	-0.7293***	-0.7590***	-0.9763***	-0.8115***
	(0.0925)	(0.0964)	(0.1200)	(0.0624)	(0.0370)
School	-1.5096***	-0.9192***	-1.1623***	-1.3117***	-1.1679***
	(0.0819)	(0.1769)	(0.1043)	(0.0545)	(0.0421)
After	-1.9698***	-1.1968***	-1.4723***	-1.5842***	-1.4196***
	(0.1139)	(0.1430)	(0.1365)	(0.0683)	(0.0584)
Style	-1.6572***	-1.1163***	-1.2574***	-1.4418***	-1.2135***
	(0.1107)	(0.0998)	(0.1287)	(0.0940)	(0.0414)
Deceased	0.1121***	0.2285***	0.1847***	0.0409	0.1785***
	(0.0308)	(0.0579)	(0.0426)	(0.0489)	(0.0192)
Pedigree	0.1798***	0.2834***	0.2586***	0.2571***	0.2573***
	(0.0227)	(0.0195)	(0.0746)	(0.0324)	(0.0206)
Exhibition	0.3478***	0.3210***	0.2996***	0.2761***	0.4359***
	(0.0148)	(0.0179)	(0.0919)	(0.0233)	(0.0163)
Literature	0.3801***	0.3687***	0.4600***	0.3881***	0.3976***
	(0.0187)	(0.0372)	(0.0653)	(0.0259)	(0.0343)
Authentication	0.0553	-0.0182	0.2077**	0.1652***	0.1689***
	(0.0665)	(0.0279)	(0.0739)	(0.0301)	(0.0397)
Constant	6.6985***	5.5176***	6.7348***	6.4740***	6.2531***
	(0.1860)	(0.2049)	(0.1595)	(0.1218)	(0.1074)
Observations	689,836	103,209	49,523	247,136	1,009,164
R-squared	0.6967	0.7369	0.6786	0.6908	0.7103
Artist FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES

Online Appendix 12 Hedonic Regressions by Artist Nationalities

This table presents the hedonic regression results by artist nationalities since 1957 including: (1) British; (2) American; and (3) Dutch & Belgian; (4) French; (5) German; (6) Italian; (7) Spanish; (8) Russian. The dependent variable is the natural log of deflated hammer price. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors are clustered at auction branch level and reported in parentheses.

Variables	(1) British	(2) American	(3) Dutch & Belgian	(4) French	(5) German	(6) Italian	(7) Spanish	(8) Russian
Abstract	-0.0575**	-0.0136	0.0853***	-0.0026	0.0443***	0.0103	-0.1165***	0.1983***
	(0.0240)	(0.0179)	(0.0152)	(0.0094)	(0.0143)	(0.0141)	(0.0263)	(0.0195)
Animals	-0.0577***	-0.0082	-0.0806***	-0.0463***	0.0001	0.0265**	-0.0416	0.0069
	(0.0084)	(0.0113)	(0.0087)	(0.0087)	(0.0131)	(0.0130)	(0.0259)	(0.0234)
Landscape	-0.0705***	0.0118	-0.0226***	-0.0525***	0.0673***	0.0308***	-0.0150	0.0073
	(0.0068)	(0.0079)	(0.0075)	(0.0063)	(0.0095)	(0.0084)	(0.0242)	(0.0179)
Seascape	0.0060	0.0796***	0.0070	0.1239***	0.0713***	0.0836***	0.1603***	-0.0688***
	(0.0090)	(0.0108)	(0.0106)	(0.0082)	(0.0139)	(0.0120)	(0.0324)	(0.0255)
Urbanscape	0.0789***	0.1344***	0.0876***	0.1135***	0.1396***	0.1944***	0.0998***	0.1273***
	(0.0071)	(0.0088)	(0.0086)	(0.0068)	(0.0113)	(0.0094)	(0.0259)	(0.0184)
Nude	-0.1423***	-0.1579***	0.0024	-0.0932***	-0.0958***	-0.1263***	-0.0166	0.0527
	(0.0162)	(0.0158)	(0.0224)	(0.0106)	(0.0169)	(0.0178)	(0.0327)	(0.0349)
People	-0.0538***	-0.0438***	0.0192**	0.0044	-0.0051	0.0588***	0.1214***	-0.0427**
	(0.0072)	(0.0100)	(0.0080)	(0.0063)	(0.0102)	(0.0082)	(0.0185)	(0.0179)
Self Portrait	0.2663***	0.2504***	0.0729	0.0777***	0.2784***	0.0213	0.2454***	-0.0045
	(0.0365)	(0.0415)	(0.0531)	(0.0281)	(0.0316)	(0.0320)	(0.0936)	(0.0602)
Portrait	-0.1114***	-0.2978***	-0.2681***	-0.1221***	-0.1499***	-0.0718***	-0.2153***	-0.0256
	(0.0113)	(0.0155)	(0.0128)	(0.0090)	(0.0157)	(0.0131)	(0.0296)	(0.0245)
Religion	0.0117	0.0121	-0.1165***	0.0384***	-0.0321	0.0086	-0.0307	0.0720*
	(0.0189)	(0.0217)	(0.0127)	(0.0109)	(0.0200)	(0.0098)	(0.0345)	(0.0372)
Still Life	0.0490***	0.0155	0.0834***	0.0682***	0.1199***	0.1184***	0.1372***	0.0798***
	(0.0111)	(0.0123)	(0.0118)	(0.0076)	(0.0147)	(0.0105)	(0.0237)	(0.0191)
Study	-0.1934***	-0.0894***	-0.0980***	-0.2387***	-0.2015***	-0.0617***	-0.2375***	-0.1780***
	(0.0124)	(0.0163)	(0.0255)	(0.0127)	(0.0220)	(0.0165)	(0.0392)	(0.0355)
Other Topic	0.0430***	0.1224***	0.0249***	0.0772***	0.0724***	0.1021***	0.0485***	0.0788***
	(0.0070)	(0.0072)	(0.0077)	(0.0061)	(0.0084)	(0.0073)	(0.0172)	(0.0161)
Height	0.0041***	0.0063***	0.0049***	0.0067***	0.0073***	0.0057***	0.0090***	0.0120***
	(0.0003)	(0.0002)	(0.0005)	(0.0003)	(0.0003)	(0.0002)	(0.0005)	(0.0006)
Width	0.0066***	0.0047***	0.0079***	0.0056***	0.0053***	0.0057***	0.0055***	0.0064***
	(0.0003)	(0.0002)	(0.0003)	(0.0004)	(0.0003)	(0.0002)	(0.0004)	(0.0004)
Height_Sqr	0.0001*	-0.0001***	-0.0001	-0.0001***	-0.0001***	-0.0001***	-0.0001***	-0.0001***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Width_Sqr	-0.0001***	-0.0001***	-0.0001***	-0.0001***	-0.0001***	-0.0001	0.0000	-0.0001***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Oil	1.0192***	1.0522***	1.0643***	1.3270***	1.2681***	1.0540***	1.2750***	1.3365***

Variables	(1) British	(2) American	(3) Dutch & Belgian	(4) French	(5) German	(6) Italian	(7) Spanish	(8) Russian
	(0.0107)	(0.0097)	(0.0117)	(0.0096)	(0.0100)	(0.0086)	(0.0174)	(0.0185)
Watercolor	0.4234***	0.3644***	0.4091***	0.5172***	0.5580***	0.1789***	0.5113***	0.5938***
	(0.0073)	(0.0087)	(0.0106)	(0.0057)	(0.0083)	(0.0102)	(0.0167)	(0.0155)
Signed	0.1203***	0.1524***	0.2629***	0.3205***	0.1723***	0.1604***	0.2598***	0.1489***
	(0.0053)	(0.0069)	(0.0065)	(0.0049)	(0.0076)	(0.0092)	(0.0182)	(0.0138)
Dated	0.1367***	0.1565***	0.1928***	0.1634***	0.1791***	0.1386***	0.2272***	0.1346***
	(0.0049)	(0.0056)	(0.0061)	(0.0045)	(0.0063)	(0.0060)	(0.0129)	(0.0101)
Inscribed	0.0009	-0.0301***	0.0638***	-0.0482***	0.0386***	0.0891***	-0.1210***	-0.0167
	(0.0049)	(0.0062)	(0.0083)	(0.0056)	(0.0064)	(0.0071)	(0.0163)	(0.0126)
Attributed	-0.6200***	-1.0587***	-0.6127***	-0.7732***	-0.6648***	-0.6615***	-0.9307***	-0.9841***
	(0.0100)	(0.0197)	(0.0083)	(0.0099)	(0.0164)	(0.0096)	(0.0434)	(0.0424)
Studio	-0.6285***	-1.0267***	-0.5767***	-0.9214***	-0.7354***	-0.7879***	-1.2099***	-0.3759***
	(0.0364)	(0.3579)	(0.0206)	(0.0292)	(0.0603)	(0.0237)	(0.0857)	(0.0755)
Circle	-0.7850***	-1.5540***	-0.9132***	-1.1948***	-0.9000***	-1.0083***	-1.5022***	-1.2643***
	(0.0152)	(0.1127)	(0.0106)	(0.0188)	(0.0277)	(0.0123)	(0.0578)	(0.1266)
School	-1.1834***	-1.5125***	-1.2360***	-1.6652***	-1.0340***	-1.3023***	-2.0896***	-1.4102***
	(0.0387)	(0.1312)	(0.0203)	(0.0287)	(0.0619)	(0.0195)	(0.0899)	(0.2136)
After	-1.4185***	-1.6515***	-1.6043***	-1.9514***	-1.4084***	-1.9177***	-2.7777***	-1.7686***
	(0.0280)	(0.0849)	(0.0192)	(0.0311)	(0.0613)	(0.0210)	(0.0844)	(0.1354)
Style	-1.1294***	-1.6783***	-1.4583***	-1.8530***	-1.4072***	-1.6164***	-2.3328***	-1.5141***
	(0.0178)	(0.0940)	(0.0103)	(0.0182)	(0.0347)	(0.0135)	(0.0588)	(0.1422)
Deceased	0.2961***	0.2022***	0.0935***	0.2134***	0.0226	-0.1202***	-0.1435***	-0.4102***
	(0.0136)	(0.0133)	(0.0181)	(0.0102)	(0.0177)	(0.0119)	(0.0257)	(0.0293)
Sotheby's London	0.8374***	0.7544***	0.6393***	0.6380***	0.6381***	0.6920***	0.6807***	0.6548***
	(0.0073)	(0.0161)	(0.0091)	(0.0069)	(0.0145)	(0.0111)	(0.0212)	(0.0146)
Sotheby's New York	0.9367***	0.7127***	0.7539***	0.7256***	0.4488***	0.6922***	0.7328***	0.5766***
	(0.0142)	(0.0084)	(0.0123)	(0.0073)	(0.0161)	(0.0134)	(0.0236)	(0.0181)
Sotheby's Other Branches	0.3488***	0.4176***	0.4430***	0.4053***	0.3006***	0.3222***	0.3465***	0.4070***
	(0.0116)	(0.0308)	(0.0082)	(0.0109)	(0.0191)	(0.0107)	(0.0289)	(0.0318)
Christie's London	0.8512***	0.7618***	0.6299***	0.6243***	0.6142***	0.6552***	0.7187***	0.6186***
	(0.0077)	(0.0186)	(0.0096)	(0.0084)	(0.0150)	(0.0118)	(0.0233)	(0.0191)
Christie's New York	0.6932***	0.5404***	0.5687***	0.6008***	0.3445***	0.5008***	0.6341***	0.3735***
	(0.0164)	(0.0088)	(0.0147)	(0.0086)	(0.0186)	(0.0156)	(0.0280)	(0.0253)
Christie's Other Branches	0.2192***	0.4339***	0.2742***	0.2892***	0.1668***	0.1843***	0.2721***	0.1090***
	(0.0066)	(0.0142)	(0.0069)	(0.0075)	(0.0150)	(0.0090)	(0.0258)	(0.0227)
Bonhams London	0.5354***	0.4075***	0.0655***	0.1706***	0.3498***	0.0122	0.1067	0.3310***
	(0.0111)	(0.0556)	(0.0227)	(0.0284)	(0.0567)	(0.0276)	(0.0966)	(0.0380)
Bonhams Other Branches	0.0521***	0.0178	-0.0767***	-0.0601***	-0.1629***	-0.0303	-0.1861***	-0.1537***
	(0.0066)	(0.0120)	(0.0219)	(0.0167)	(0.0342)	(0.0267)	(0.0695)	(0.0519)
Phillips London	0.4769***	0.6483***	0.1665***	0.0927***	0.1872***	0.0920***	0.1090	0.0274
	(0.0111)	(0.0314)	(0.0167)	(0.0240)	(0.0349)	(0.0204)	(0.0677)	(0.0611)
Phillips New York	0.3520***	0.4045***	0.1919***	0.2405***	0.3599***	0.3205***	0.2167	0.3113***
	(0.0473)	(0.0178)	(0.0584)	(0.0472)	(0.0481)	(0.0801)	(0.1382)	(0.0921)
Auction_American	-0.0262*	-0.0419***	-0.1514***	-0.1063***	-0.2737***	-0.1951***	-0.1863***	-0.2413***
	(0.0147)	(0.0070)	(0.0176)	(0.0113)	(0.0229)	(0.0194)	(0.0433)	(0.0298)
Auction_European	0.2170***	0.2090***	0.3200***	0.1319***	0.1474***	0.2852***	0.0147	0.0942***

Variables	(1) British	(2) American	(3) Dutch & Belgian	(4) French	(5) German	(6) Italian	(7) Spanish	(8) Russian
	(0.0110)	(0.0146)	(0.0075)	(0.0045)	(0.0066)	(0.0068)	(0.0196)	(0.0130)
Pedigree	0.3052***	0.3104***	0.3440***	0.3041***	0.3389***	0.3220***	0.3101***	0.3233***
	(0.0065)	(0.0070)	(0.0081)	(0.0059)	(0.0092)	(0.0094)	(0.0179)	(0.0134)
Exhibition	0.3868***	0.3800***	0.5093***	0.4442***	0.4252***	0.3441***	0.3787***	0.3122***
	(0.0101)	(0.0109)	(0.0136)	(0.0097)	(0.0152)	(0.0151)	(0.0225)	(0.0225)
Literature	0.5013***	0.5272***	0.4893***	0.3936***	0.4621***	0.4482***	0.5304***	0.3908***
	(0.0134)	(0.0137)	(0.0126)	(0.0084)	(0.0155)	(0.0117)	(0.0225)	(0.0227)
Authentication	0.1167***	0.2299***	0.2137***	0.2836***	0.2422***	0.0628***	0.0421	0.3210***
	(0.0383)	(0.0208)	(0.0275)	(0.0129)	(0.0223)	(0.0075)	(0.0337)	(0.0322)
Constant	4.9797***	4.8200***	5.3153***	5.5007***	5.1748***	5.6711***	5.6504***	5.5215***
	(0.0731)	(0.3338)	(0.0676)	(0.0557)	(0.3318)	(0.1045)	(0.3361)	(0.4759)
Observations	265,178	252,805	231,184	417,513	158,157	218,228	44,503	59,235
R-squared	0.6769	0.7702	0.6739	0.7565	0.7384	0.7596	0.7876	0.7527
Artist FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES	YES	YES

Online Appendix 13 Hedonic Regressions by Artist Nationalities since 1970

This table presents the hedonic regression results by artist nationalities since 1970 including: (1) British; (2) American; and (3) Dutch & Belgian; (4) French; (5) German; (6) Italian; (7) Spanish; (8) Russian; (9) Chinese. The dependent variable is the natural log of deflated hammer price. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors are clustered at auction branch level and reported in parentheses.

Variables	(1) British	(2) American	(3) Dutch & Belgian	(4) French	(5) German	(6) Italian	(7) Spanish	(8) Russian	(9) Chinese
Abstract	-0.0557**	-0.0130	0.0868***	-0.0015	0.0442***	0.0104	-0.1122***	0.1988***	0.1436***
	(0.0243)	(0.0179)	(0.0152)	(0.0094)	(0.0143)	(0.0141)	(0.0264)	(0.0195)	(0.0369)
Animals	-0.0540***	-0.0083	-0.0762***	-0.0440***	-0.0010	0.0270**	-0.0472*	0.0072	0.2900***
	(0.0084)	(0.0113)	(0.0088)	(0.0087)	(0.0132)	(0.0130)	(0.0261)	(0.0236)	(0.0154)
Landscape	-0.0723***	0.0116	-0.0230***	-0.0511***	0.0673***	0.0273***	-0.0161	0.0093	0.6165***
	(0.0069)	(0.0079)	(0.0076)	(0.0064)	(0.0096)	(0.0084)	(0.0243)	(0.0179)	(0.0139)
Seascape	0.0088	0.0795***	0.0080	0.1237***	0.0706***	0.0851***	0.1576***	-0.0707***	0.2615***
	(0.0091)	(0.0108)	(0.0107)	(0.0083)	(0.0139)	(0.0120)	(0.0325)	(0.0254)	(0.0348)
Urbanscape	0.0776***	0.1345***	0.0875***	0.1138***	0.1402***	0.1896***	0.0955***	0.1281***	0.3109***
	(0.0072)	(0.0088)	(0.0087)	(0.0069)	(0.0113)	(0.0094)	(0.0259)	(0.0184)	(0.0230)
Nude	-0.1333***	-0.1574***	0.0047	-0.0901***	-0.0962***	-0.1240***	-0.0236	0.0535	0.1205**
	(0.0165)	(0.0158)	(0.0225)	(0.0107)	(0.0169)	(0.0178)	(0.0329)	(0.0351)	(0.0520)
People	-0.0565***	-0.0434***	0.0200**	0.0049	-0.0075	0.0610***	0.1217***	-0.0423**	0.3100***
	(0.0073)	(0.0100)	(0.0081)	(0.0063)	(0.0102)	(0.0083)	(0.0186)	(0.0180)	(0.0185)
Self Portrait	0.2645***	0.2493***	0.0733	0.0778***	0.2772***	0.0186	0.2464***	-0.0046	0.6040***
	(0.0366)	(0.0416)	(0.0530)	(0.0283)	(0.0316)	(0.0321)	(0.0943)	(0.0609)	(0.0798)
Portrait	-0.1137***	-0.3017***	-0.2718***	-0.1252***	-0.1504***	-0.0733***	-0.2133***	-0.0273	0.3738***
	(0.0115)	(0.0155)	(0.0130)	(0.0090)	(0.0157)	(0.0132)	(0.0298)	(0.0246)	(0.0359)
Religion	0.0122	0.0151	-0.1180***	0.0374***	-0.0264	0.0119	-0.0269	0.0685*	0.4917***
	(0.0193)	(0.0217)	(0.0129)	(0.0110)	(0.0199)	(0.0099)	(0.0349)	(0.0373)	(0.0525)
Still Life	0.0485***	0.0153	0.0796***	0.0664***	0.1201***	0.1184***	0.1292***	0.0815***	0.4046***
	(0.0112)	(0.0123)	(0.0119)	(0.0077)	(0.0147)	(0.0106)	(0.0237)	(0.0192)	(0.0170)
Study	-0.1914***	-0.0885***	-0.0971***	-0.2412***	-0.2137***	-0.0644***	-0.2393***	-0.1781***	0.6028***
	(0.0126)	(0.0164)	(0.0258)	(0.0129)	(0.0219)	(0.0166)	(0.0396)	(0.0357)	(0.0919)
Other Topic	0.0438***	0.1222***	0.0265***	0.0771***	0.0723***	0.1020***	0.0498***	0.0790***	0.5017***
	(0.0071)	(0.0072)	(0.0078)	(0.0061)	(0.0085)	(0.0073)	(0.0172)	(0.0162)	(0.0128)
Height	0.0041***	0.0063***	0.0051***	0.0068***	0.0074***	0.0058***	0.0091***	0.0120***	0.0054***
	(0.0003)	(0.0002)	(0.0005)	(0.0003)	(0.0003)	(0.0002)	(0.0005)	(0.0006)	(0.0002)

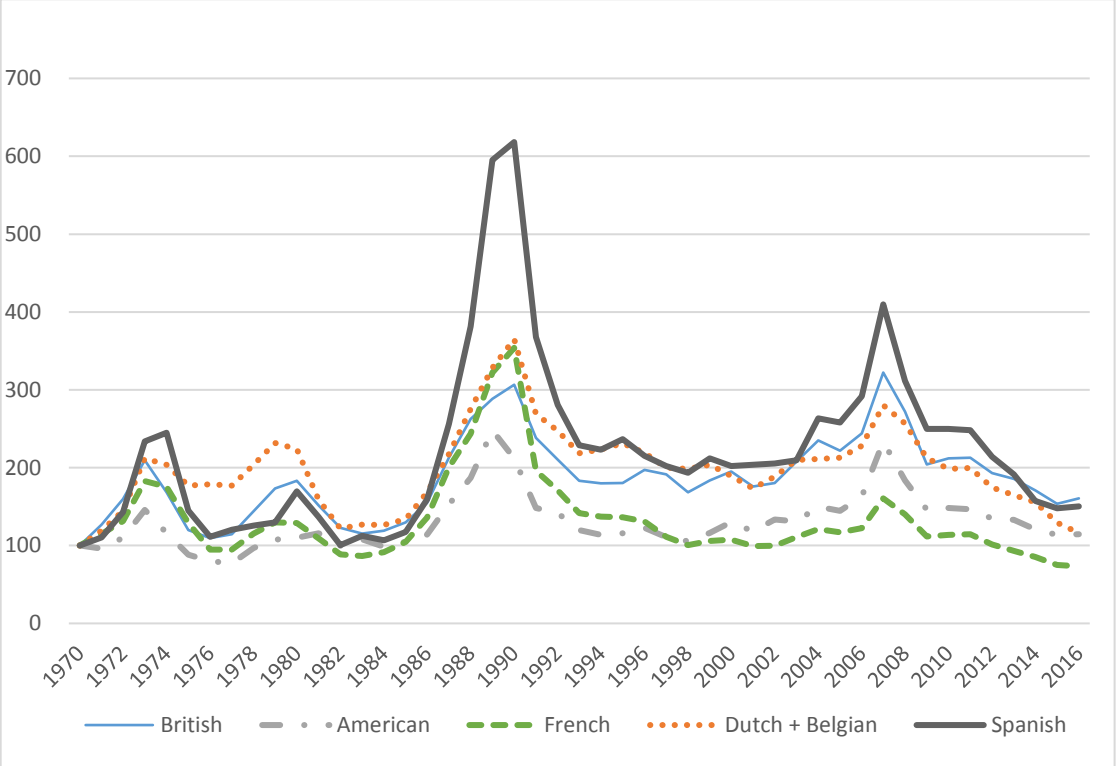
Variables	(1) British	(2) American	(3) Dutch & Belgian	(4) French	(5) German	(6) Italian	(7) Spanish	(8) Russian	(9) Chinese
Width	0.0068***	0.0047***	0.0080***	0.0056***	0.0053***	0.0058***	0.0056***	0.0064***	0.0056***
	(0.0003)	(0.0002)	(0.0003)	(0.0004)	(0.0003)	(0.0002)	(0.0004)	(0.0004)	(0.0002)
Height_Sqr	0.0001*	-0.0001***	-0.0001	-0.0001***	-0.0001***	-0.0001***	-0.0001***	-0.0001***	-0.0001***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Width_Sqr	-0.0001***	-0.0001***	-0.0001***	-0.0001***	-0.0001***	-0.0001	0.0001	-0.0001***	-0.0001***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Oil	1.0506***	1.0543***	1.0672***	1.3316***	1.2708***	1.0663***	1.2753***	1.3389***	1.2498***
	(0.0110)	(0.0097)	(0.0117)	(0.0098)	(0.0100)	(0.0087)	(0.0175)	(0.0185)	(0.0248)
Watercolor	0.4514***	0.3655***	0.4140***	0.5205***	0.5597***	0.1859***	0.5116***	0.5939***	0.2997***
	(0.0075)	(0.0088)	(0.0106)	(0.0058)	(0.0083)	(0.0102)	(0.0167)	(0.0155)	(0.0100)
Signed	0.1215***	0.1517***	0.2586***	0.3180***	0.1720***	0.1577***	0.2564***	0.1479***	-0.0375***
	(0.0054)	(0.0069)	(0.0066)	(0.0050)	(0.0076)	(0.0093)	(0.0182)	(0.0138)	(0.0116)
Dated	0.1365***	0.1570***	0.1929***	0.1627***	0.1788***	0.1384***	0.2280***	0.1349***	0.2964***
	(0.0049)	(0.0056)	(0.0062)	(0.0046)	(0.0063)	(0.0060)	(0.0130)	(0.0101)	(0.0082)
Inscribed	-0.0010	-0.0313***	0.0632***	-0.0511***	0.0384***	0.0874***	-0.1238***	-0.0169	0.0252**
	(0.0049)	(0.0062)	(0.0084)	(0.0057)	(0.0064)	(0.0071)	(0.0164)	(0.0126)	(0.0124)
Attributed	-0.6212***	-1.0587***	-0.6183***	-0.7816***	-0.6632***	-0.6620***	-0.9479***	-0.9861***	-1.5972***
	(0.0100)	(0.0197)	(0.0084)	(0.0099)	(0.0164)	(0.0097)	(0.0444)	(0.0425)	(0.0575)
Studio	-0.6467***	-1.0389***	-0.5861***	-0.9446***	-0.7451***	-0.7988***	-1.2177***	-0.3746***	0.2815
	(0.0366)	(0.3598)	(0.0208)	(0.0294)	(0.0602)	(0.0238)	(0.0873)	(0.0755)	(0.3908)
Circle	-0.7940***	-1.5617***	-0.9203***	-1.2169***	-0.8913***	-1.0169***	-1.5123***	-1.2717***	
	(0.0153)	(0.1130)	(0.0107)	(0.0189)	(0.0278)	(0.0123)	(0.0589)	(0.1268)	
School	-1.1925***	-1.5139***	-1.2377***	-1.6901***	-1.0192***	-1.3145***	-2.0981***	-1.4190***	-0.0401
	(0.0391)	(0.1317)	(0.0203)	(0.0289)	(0.0624)	(0.0196)	(0.0919)	(0.2140)	(0.5443)
After	-1.4356***	-1.6487***	-1.5976***	-1.9720***	-1.3906***	-1.9308***	-2.7740***	-1.7749***	-0.6585***
	(0.0284)	(0.0856)	(0.0192)	(0.0313)	(0.0613)	(0.0212)	(0.0868)	(0.1360)	(0.1967)
Style	-1.1423***	-1.6764***	-1.4600***	-1.8760***	-1.3983***	-1.6261***	-2.3411***	-1.5233***	-0.8419***
	(0.0180)	(0.0940)	(0.0104)	(0.0184)	(0.0349)	(0.0136)	(0.0603)	(0.1424)	(0.1648)
Deceased	0.2937***	0.2012***	0.0932***	0.2189***	0.0210	-0.1306***	-0.1441***	-0.4316***	0.1199***
	(0.0148)	(0.0134)	(0.0182)	(0.0103)	(0.0179)	(0.0119)	(0.0262)	(0.0297)	(0.0264)
Sotheby's London	0.8283***	0.7493***	0.6226***	0.6188***	0.6320***	0.6777***	0.6648***	0.6553***	0.3598***
	(0.0073)	(0.0162)	(0.0093)	(0.0070)	(0.0146)	(0.0113)	(0.0212)	(0.0146)	(0.0518)
Sotheby's New York	0.9236***	0.7118***	0.7487***	0.7207***	0.4482***	0.6867***	0.7297***	0.5771***	0.7336***
	(0.0142)	(0.0084)	(0.0123)	(0.0074)	(0.0161)	(0.0134)	(0.0236)	(0.0181)	(0.0289)
Sotheby's Other Branches	0.3486***	0.4190***	0.4427***	0.4018***	0.3007***	0.3205***	0.3456***	0.4077***	0.4913***
	(0.0116)	(0.0308)	(0.0082)	(0.0109)	(0.0191)	(0.0107)	(0.0289)	(0.0318)	(0.0165)
Christie's London	0.8502***	0.7716***	0.6389***	0.6443***	0.6195***	0.6654***	0.7301***	0.6174***	0.2077***

Variables	(1) British	(2) American	(3) Dutch & Belgian	(4) French	(5) German	(6) Italian	(7) Spanish	(8) Russian	(9) Chinese
	(0.0078)	(0.0188)	(0.0099)	(0.0086)	(0.0152)	(0.0121)	(0.0236)	(0.0192)	(0.0546)
Christie's New York	0.6826***	0.5396***	0.5633***	0.5963***	0.3438***	0.4966***	0.6322***	0.3726***	0.5293***
	(0.0164)	(0.0088)	(0.0147)	(0.0086)	(0.0186)	(0.0156)	(0.0280)	(0.0253)	(0.0382)
Christie's Other Branches	0.2191***	0.4346***	0.2730***	0.2874***	0.1662***	0.1823***	0.2710***	0.1095***	0.1698***
	(0.0066)	(0.0142)	(0.0069)	(0.0075)	(0.0150)	(0.0090)	(0.0258)	(0.0227)	(0.0141)
Bonhams London	0.5310***	0.4118***	0.0608***	0.1685***	0.3502***	0.0059	0.1014	0.3317***	-0.0154
	(0.0111)	(0.0557)	(0.0227)	(0.0284)	(0.0567)	(0.0277)	(0.0965)	(0.0380)	(0.1143)
Bonhams Other Branches	0.0525***	0.0184	-0.0794***	-0.0603***	-0.1628***	-0.0325	-0.1817***	-0.1516***	-0.7443***
	(0.0066)	(0.0120)	(0.0219)	(0.0167)	(0.0342)	(0.0268)	(0.0696)	(0.0519)	(0.0266)
Phillips London	0.4767***	0.6499***	0.1627***	0.0920***	0.1864***	0.0885***	0.1079	0.0258	0.2815***
	(0.0112)	(0.0314)	(0.0167)	(0.0240)	(0.0349)	(0.0204)	(0.0677)	(0.0611)	(0.0664)
Phillips New York	0.3428***	0.4042***	0.1898***	0.2379***	0.3592***	0.3157***	0.2155	0.3129***	0.3075***
	(0.0474)	(0.0178)	(0.0583)	(0.0472)	(0.0481)	(0.0801)	(0.1381)	(0.0920)	(0.0964)
Auction_American	-0.0283*	-0.0420***	-0.1536***	-0.1069***	-0.2739***	-0.1980***	-0.1864***	-0.2392***	-0.8258***
	(0.0147)	(0.0070)	(0.0176)	(0.0113)	(0.0230)	(0.0194)	(0.0434)	(0.0298)	(0.0708)
Auction_European	0.2149***	0.2091***	0.3183***	0.1310***	0.1474***	0.2834***	0.0137	0.0940***	-0.3963***
	(0.0110)	(0.0146)	(0.0075)	(0.0045)	(0.0066)	(0.0068)	(0.0196)	(0.0130)	(0.0358)
Pedigree	0.3039***	0.3096***	0.3497***	0.3059***	0.3393***	0.3265***	0.3142***	0.3239***	0.0334***
	(0.0066)	(0.0070)	(0.0081)	(0.0060)	(0.0092)	(0.0094)	(0.0181)	(0.0134)	(0.0123)
Exhibition	0.3946***	0.3819***	0.4828***	0.4416***	0.4234***	0.3246***	0.3690***	0.3122***	0.1859***
	(0.0103)	(0.0109)	(0.0139)	(0.0100)	(0.0153)	(0.0153)	(0.0227)	(0.0227)	(0.0201)
Literature	0.4964***	0.5286***	0.4872***	0.3933***	0.4613***	0.4445***	0.5302***	0.3895***	0.4056***
	(0.0135)	(0.0137)	(0.0129)	(0.0085)	(0.0155)	(0.0118)	(0.0228)	(0.0229)	(0.0182)
Authentication	0.1170***	0.2299***	0.2117***	0.2830***	0.2414***	0.0626***	0.0437	0.3204***	0.1055***
	(0.0384)	(0.0208)	(0.0275)	(0.0129)	(0.0222)	(0.0075)	(0.0338)	(0.0321)	(0.0394)
February	0.0091	0.0880***	-0.2101***	-0.0303***	0.1235***	-0.2434***	-0.0589*	0.1207***	0.2182***
	(0.0119)	(0.0134)	(0.0143)	(0.0115)	(0.0238)	(0.0131)	(0.0333)	(0.0361)	(0.0755)
March	0.1490***	0.0630***	-0.0616***	0.1049***	0.0445**	-0.1033***	0.0347	0.2369***	0.0635**
	(0.0101)	(0.0130)	(0.0130)	(0.0108)	(0.0225)	(0.0113)	(0.0336)	(0.0342)	(0.0312)
April	0.1867***	0.2482***	0.0205	0.1271***	0.1225***	-0.0954***	0.0358	0.3091***	0.4098***
	(0.0110)	(0.0132)	(0.0129)	(0.0112)	(0.0223)	(0.0116)	(0.0343)	(0.0345)	(0.0296)
May	0.1872***	0.4312***	-0.0114	0.1813***	0.2541***	-0.0848***	0.1857***	0.3885***	0.7305***
	(0.0109)	(0.0124)	(0.0127)	(0.0108)	(0.0216)	(0.0110)	(0.0320)	(0.0338)	(0.0297)
June	0.2423***	0.1572***	0.0031	0.1735***	0.2434***	-0.1000***	0.0689**	0.4548***	0.5388***
	(0.0104)	(0.0132)	(0.0129)	(0.0107)	(0.0215)	(0.0112)	(0.0322)	(0.0331)	(0.0287)
July	0.1484***	0.2152***	0.0798***	0.0493***	0.0694***	-0.0083	-0.0034	0.0558	0.5414***
	(0.0106)	(0.0156)	(0.0152)	(0.0126)	(0.0255)	(0.0135)	(0.0389)	(0.0395)	(0.0299)

Variables	(1) British	(2) American	(3) Dutch & Belgian	(4) French	(5) German	(6) Italian	(7) Spanish	(8) Russian	(9) Chinese
August	0.0754***	0.1987***	-0.4317***	0.0323	-0.1346***	-0.6347***	-0.1738**	-0.0095	-0.2732***
	(0.0146)	(0.0150)	(0.0321)	(0.0203)	(0.0436)	(0.0449)	(0.0785)	(0.0567)	(0.0492)
September	0.0470***	0.0020	-0.2553***	-0.1674***	0.0368	-0.2731***	-0.1793***	0.0361	0.0284
	(0.0109)	(0.0128)	(0.0144)	(0.0135)	(0.0230)	(0.0131)	(0.0380)	(0.0395)	(0.0327)
October	0.0687***	0.1323***	-0.0536***	-0.0265**	0.1034***	-0.1545***	-0.0647**	0.2097***	0.4488***
	(0.0106)	(0.0130)	(0.0126)	(0.0109)	(0.0220)	(0.0115)	(0.0329)	(0.0344)	(0.0292)
November	0.2495***	0.3836***	0.0234*	0.1959***	0.2671***	-0.0719***	0.2003***	0.4409***	0.5858***
	(0.0099)	(0.0124)	(0.0126)	(0.0107)	(0.0214)	(0.0109)	(0.0320)	(0.0330)	(0.0299)
December	0.2188***	0.3212***	0.0338***	0.1392***	0.1938***	-0.0369***	0.0962***	0.3345***	0.6556***
	(0.0109)	(0.0131)	(0.0128)	(0.0107)	(0.0217)	(0.0114)	(0.0322)	(0.0334)	(0.0286)
Constant	5.4144***	5.9915***	6.2552***	6.3519***	5.9181***	6.3343***	6.5042***	5.8737***	3.1203***
	(0.0386)	(0.0855)	(0.0429)	(0.0323)	(0.0770)	(0.0525)	(0.1557)	(0.0930)	(0.2602)
Observations	257,782	252,286	224,429	410,628	157,490	214,395	43,934	58,872	114,753
R-squared	0.6831	0.7705	0.6790	0.7578	0.7390	0.7633	0.7899	0.7535	0.6312
Artist FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES	YES	YES	YES

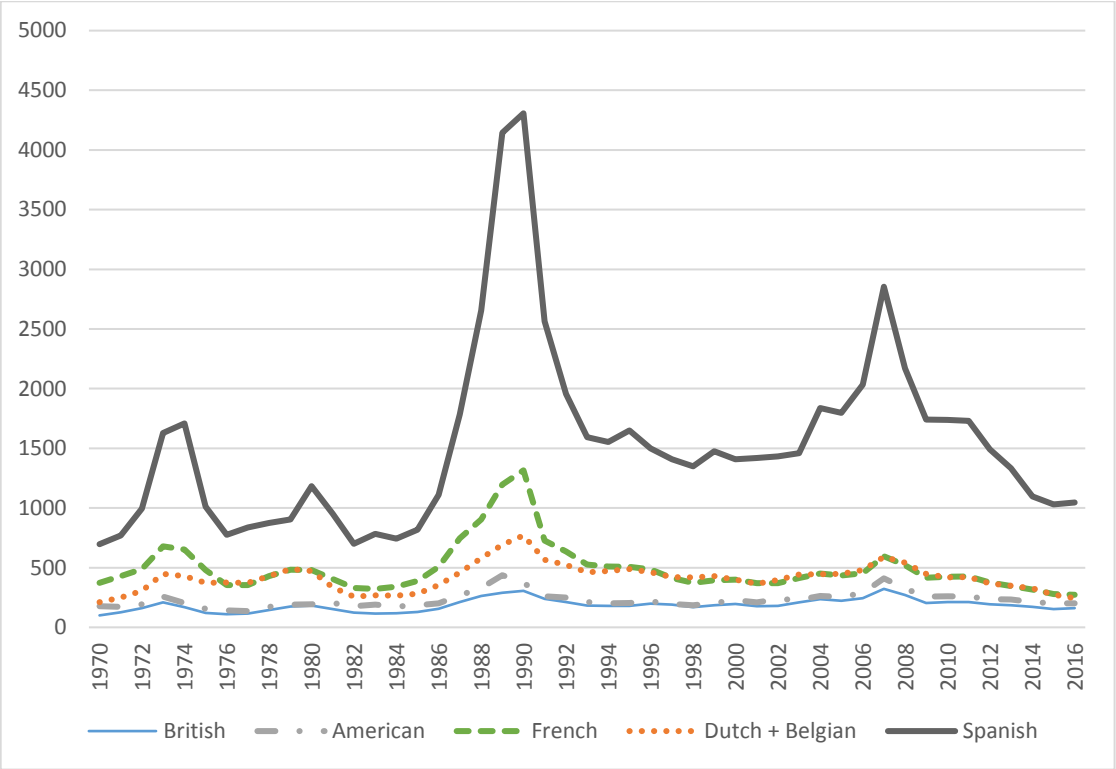
Online Appendix 14 Price Indices of Artists Nationality since 1970 (Indices Initial Values = 100)

This figure presents the art price indices of British, American; French, Dutch & Belgian, and Spanish artists since 1970 detailed in Online Appendix 13. The initial indices values are set to be 100 in year 1957.



Online Appendix 15 Price Indices of Artists Nationality since 1970 (Relative Indices Initial Values)

This figure presents the art price indices of British, American; French, Dutch & Belgian, and Spanish artists since 1970 detailed in Online Appendix 13. The initial index value for British artists is set to be 100 in 1957 and the initial indices values are normalized by the average prices from 1957 to 1961 relative to British artists'.



Online Appendix 16 Hedonic Regressions by Local and International Markets

This table presents the hedonic regression results by local and international markets since 1957. The observations are defined as Local when the artist nationality is the same as the sale country. The observations are defined as International when the artist nationality is different from the sale country. The dependent variable is the natural log of deflated hammer price. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors are clustered at auction branch level and reported in parentheses.

	(1)	(2)
Variables	Local	International
Abstract	0.0425	-0.0322**
	(0.0314)	(0.0138)
Animals	0.0212	-0.0556***
	(0.0323)	(0.0075)
Landscape	0.0655	-0.0099
	(0.0471)	(0.0067)
Seascape	0.1186***	0.0359***
	(0.0308)	(0.0080)
Urbanscape	0.1576***	0.1067***
	(0.0268)	(0.0075)
Nude	-0.0599*	-0.0825***
	(0.0345)	(0.0114)
People	0.0425	0.0089
	(0.0273)	(0.0064)
Self Portrait	0.2115***	0.1677***
	(0.0407)	(0.0284)
Portrait	-0.1584***	-0.1374***
	(0.0285)	(0.0086)
Religion	0.0551*	-0.0351**
	(0.0298)	(0.0177)
Still Life	0.1059***	0.1101***
	(0.0390)	(0.0104)
Study	-0.1590***	-0.1500***
	(0.0237)	(0.0163)
Other Topic	0.1303***	0.0628***
	(0.0416)	(0.0078)
Height	0.0062***	0.0057***
	(0.0003)	(0.0003)
Width	0.0054***	0.0056***
	(0.0002)	(0.0002)
Height_Sqr	-0.0001***	-0.0001***
	(0.0000)	(0.0000)
Width_Sqr	-0.0001***	-0.0001***
	(0.0000)	(0.0000)
Oil	1.2363***	1.1731***
	(0.0251)	(0.0328)
Watercolor	0.4761***	0.3996***
	(0.0233)	(0.0192)
Signed	0.1753***	0.2259***
	(0.0196)	(0.0229)
Dated	0.1585***	0.1859***
	(0.0106)	(0.0050)
Inscribed	-0.0040	-0.0010
	(0.0102)	(0.0101)
Attributed	-0.7310***	-0.6986***
	(0.0235)	(0.0376)
Studio	-0.8177***	-0.7077***
	(0.0443)	(0.0752)
Circle	-0.9264***	-1.0037***

Variables	(1) Local	(2) International
	(0.0489)	(0.0742)
School	-1.3192***	-1.3495***
	(0.0462)	(0.1269)
After	-1.5935***	-1.7742***
	(0.0605)	(0.0910)
Style	-1.3654***	-1.5715***
	(0.0630)	(0.0850)
Deceased	0.1582***	0.0956***
	(0.0206)	(0.0259)
Sotheby's London	0.6828***	0.7332***
	(0.0457)	(0.0359)
Sotheby's New York	0.5589***	0.7649***
	(0.0755)	(0.0457)
Sotheby's Other Branches	0.2840***	0.4054***
	(0.0434)	(0.0798)
Christie's London	0.6970***	0.7177***
	(0.0456)	(0.0364)
Christie's New York	0.4397***	0.6063***
	(0.0687)	(0.0392)
Christie's Other Branches	0.1675***	0.2586***
	(0.0441)	(0.1002)
Bonhams London	0.4404***	0.2794***
	(0.0367)	(0.0494)
Bonhams Other Branches	0.0417	-0.0654
	(0.0642)	(0.0915)
Phillips London	0.3443***	0.2586***
	(0.0425)	(0.0352)
Phillips New York	0.3508***	0.3425***
	(0.0653)	(0.0344)
Auction_American	-0.0743	-0.1225**
	(0.0504)	(0.0508)
Auction_European	0.1000***	0.2496***
	(0.0344)	(0.0449)
Pedigree	0.3379***	0.2760***
	(0.0215)	(0.0319)
Exhibition	0.3925***	0.4054***
	(0.0156)	(0.0139)
Literature	0.4037***	0.4453***
	(0.0188)	(0.0231)
Authentication	0.0726***	0.1938***
	(0.0280)	(0.0411)
Constant	5.0926***	5.6405***
	(0.1034)	(0.1708)
Observations	1,322,212	825,333
R-squared	0.7306	0.7299
Artist FE	YES	YES
Year FE	YES	YES
Month FE	YES	YES

Online Appendix 17 Hedonic Regressions by Local and International Markets since 1970 (Excluding British and American Artists)

This table presents the hedonic regression results by local and international markets since 1970 excluding British and American artists. The observations are defined as Local when the artist nationality (excluding British and American artists) is the same as the sale country. The observations are defined as International when the artist nationality (excluding British and American artists) is different from the sale country. The dependent variable is the natural log of deflated hammer price. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors are clustered at auction branch level and reported in parentheses.

	(1)	(2)
Variables	Local	International
Abstract	0.0671	-0.0260**
	(0.0444)	(0.0131)
Animals	0.0499	-0.0536***
	(0.0466)	(0.0074)
Landscape	0.1133*	-0.0069
	(0.0671)	(0.0067)
Seascape	0.1583***	0.0360***
	(0.0431)	(0.0089)
Urbanscape	0.1837***	0.1085***
	(0.0385)	(0.0072)
Nude	-0.0135	-0.0756***
	(0.0476)	(0.0115)
People	0.0858**	0.0174**
	(0.0396)	(0.0074)
Self Portrait	0.2077***	0.1652***
	(0.0549)	(0.0292)
Portrait	-0.1289***	-0.1450***
	(0.0380)	(0.0111)
Religion	0.0751*	-0.0363**
	(0.0416)	(0.0183)
Still Life	0.1353**	0.1138***
	(0.0547)	(0.0098)
Study	-0.1779***	-0.1619***
	(0.0339)	(0.0175)
Other Topic	0.1525**	0.0628***
	(0.0591)	(0.0083)
Height	0.0066***	0.0057***
	(0.0002)	(0.0003)
Width	0.0058***	0.0057***
	(0.0003)	(0.0002)
Height_Sqr	-0.0001***	-0.0001***
	(0.0000)	(0.0000)
Width_Sqr	-0.0001***	-0.0001***
	(0.0000)	(0.0000)
Oil	1.2892***	1.2054***
	(0.0232)	(0.0323)
Watercolor	0.4889***	0.4097***
	(0.0294)	(0.0179)
Signed	0.1924***	0.2436***
	(0.0283)	(0.0207)
Dated	0.1643***	0.1867***
	(0.0144)	(0.0052)
Inscribed	0.0088	0.0004
	(0.0134)	(0.0113)
Attributed	-0.7168***	-0.7111***
	(0.0186)	(0.0386)

Variables	(1) Local	(2) International
Studio	-0.9325***	-0.7368***
	(0.0532)	(0.0773)
Circle	-1.0275***	-1.0308***
	(0.0370)	(0.0733)
School	-1.4042***	-1.3846***
	(0.0532)	(0.1305)
After	-1.6261***	-1.8148***
	(0.1013)	(0.0969)
Style	-1.5162***	-1.6057***
	(0.0747)	(0.0850)
Deceased	0.1528***	0.0656**
	(0.0245)	(0.0321)
Sotheby's London		0.7216***
		(0.0341)
Sotheby's New York		0.7576***
		(0.0469)
Christie's London		0.7336***
		(0.0354)
Christie's New York		0.6075***
		(0.0411)
Bonhams London		0.2724***
		(0.0502)
Phillips London		0.2294***
		(0.0349)
Phillips New York		0.3424***
		(0.0371)
Sotheby's Other Branches	0.2766***	0.4111***
	(0.0516)	(0.0844)
Christie's Other Branches	0.1423***	0.2585***
	(0.0529)	(0.0987)
Bonhams Other Branches	0.0479	-0.0724
	(0.2088)	(0.0954)
Auction_American	-1.1422***	-0.1313***
	(0.2256)	(0.0506)
Auction_European	0.0832***	0.2508***
	(0.0310)	(0.0456)
Pedigree	0.2846***	0.2730***
	(0.0182)	(0.0334)
Exhibition	0.3565***	0.3938***
	(0.0152)	(0.0138)
Literature	0.3759***	0.4354***
	(0.0216)	(0.0236)
Authentication	0.0680**	0.1868***
	(0.0311)	(0.0445)
Constant	6.2304***	6.4108***
	(0.1135)	(0.1479)
Observations	897,452	723,458
R-squared	0.7333	0.7285
Artist FE	YES	YES
Year FE	YES	YES
Month FE	YES	YES

Online Appendix 18 Hedonic Regressions by Local and International Markets since 1970 (Sotheby's & Christie's London and New York Branches as International)

This table presents the hedonic regression results of local and international markets since 1970. The observations are defined as International when the observations were sold at Sotheby's London, Sotheby's New York, Christie's London or Christie's New York and the observations are defined as Local otherwise. The dependent variable is the natural log of deflated hammer price. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors are clustered at auction branch level and reported in parentheses.

	(1)	(2)
Variables	Local	International
Abstract	-0.0040	-0.0309
	(0.0246)	(0.0218)
Animals	0.0026	-0.0678***
	(0.0242)	(0.0097)
Landscape	0.0449	-0.0158
	(0.0368)	(0.0246)
Seascape	0.0944***	0.0416
	(0.0235)	(0.0251)
Urbanscape	0.1343***	0.1224***
	(0.0207)	(0.0171)
Nude	-0.0596**	-0.1195***
	(0.0260)	(0.0129)
People	0.0325	0.0006
	(0.0203)	(0.0153)
Self Portrait	0.1557***	0.2937***
	(0.0323)	(0.0332)
Portrait	-0.1510***	-0.1527***
	(0.0207)	(0.0051)
Religion	0.0391	-0.0571
	(0.0239)	(0.0308)
Still Life	0.0892***	0.1286***
	(0.0303)	(0.0128)
Study	-0.1600***	-0.1509***
	(0.0200)	(0.0213)
Other Topic	0.1087***	0.0736*
	(0.0322)	(0.0259)
Height	0.0059***	0.0085***
	(0.0003)	(0.0010)
Width	0.0055***	0.0062***
	(0.0002)	(0.0002)
Height_Sqr	-0.0000***	-0.0000
	(0.0000)	(0.0000)
Width_Sqr	-0.0000***	-0.0000**
	(0.0000)	(0.0000)
Oil	1.2033***	1.1740***
	(0.0209)	(0.0267)
Watercolor	0.4513***	0.4193***
	(0.0200)	(0.0117)
Signed	0.1484***	0.2615***
	(0.0191)	(0.0094)
Dated	0.1700***	0.1623***
	(0.0094)	(0.0052)
Inscribed	0.0101	-0.0405**
	(0.0097)	(0.0122)
Attributed	-0.7323***	-0.7368***
	(0.0265)	(0.0732)
Studio	-0.6327***	-1.0146***

	(0.0532)	(0.0838)
Circle	-0.9071***	-1.1759***
	(0.0538)	(0.0807)
School	-1.1954***	-1.5724***
	(0.0580)	(0.0784)
After	-1.5715***	-2.0953***
	(0.0540)	(0.0946)
Style	-1.4418***	-1.7786***
	(0.0473)	(0.1596)
Deceased	0.1428***	0.0524
	(0.0213)	(0.0313)
Sotheby's London		0.1626*
		(0.0587)
Sotheby's New York		0.1668***
		(0.0033)
Christie's London		0.1781**
		(0.0559)
Sotheby's Other Branches	0.3359***	
	(0.0432)	
Christie's Other Branches	0.2166***	
	(0.0650)	
Bonhams London	0.2976***	
	(0.0320)	
Bonhams Other Branches	-0.0063	
	(0.0673)	
Phillips London	0.2046***	
	(0.0271)	
Phillips New York	0.2924***	
	(0.0333)	
Auction_American	-0.1180***	
	(0.0345)	
Auction_European	0.1508***	
	(0.0308)	
Pedigree	0.2983***	0.1495**
	(0.0171)	(0.0405)
Exhibition	0.3741***	0.3631***
	(0.0174)	(0.0186)
Literature	0.4240***	0.3404***
	(0.0236)	(0.0083)
Authentication	0.1452***	0.0287
	(0.0332)	(0.0891)
Constant	6.3345***	7.0878***
	(0.0927)	(0.0684)
Observations	1,673,884	454,825
R-squared	0.7040	0.6918
Artist FE	YES	YES
Year FE	YES	YES
Month FE	YES	YES

Chapter 2. Colors, Emotions, and the Auction Value of Paintings

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ABSTRACT

We study the impact of colors of paintings on prices in the art auction market and incorporate color attributes of non-figurative paintings in pricing models. A one standard deviation increase in the percentages of blue (red) hue leads to premiums of 10.63% (4.20%). We also conduct laboratory experiments in China, the Netherlands, and U.S., and elicit participants' willingness-to-pay and emotions (pleasure-arousal). Blue (red) paintings command 18.57% (17.28%) higher bids and stronger intention to purchase. Although abstract art is visually arousing, it is the emotional pleasure channel that relates colors and prices. Our results are consistent across all three cultures.

Keywords: Emotion, auction, art investment, cultural economics.

JEL Code: C91, D44, G20, G11, Z11

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"The final question is the most important, and the most elusive. Has the painting got 'wallpower', the visceral impact that makes people want to own it? This is a matter of factors such as composition, colour (blue and red tend to be good news) and emotional power."

–Philip Hook, What sells art? [1]

1. Introduction

Owning objects of art generates consumption value by means of an aesthetic dividend, as one usually enjoys having a painting or photograph on the wall or a sculpture in the garden. However, art is also often considered as an alternative asset class in its own right. High-net-worth individuals (HNWIs) hold on average 9% of their investment portfolios in art and other types of collectibles (such as Bordeaux wines, classic cars, superior watches, etc.). The total value of collectibles held by HNWIs is estimated at more than USD 4 trillion (Deloitte, 2013). Purchases of art through auction houses and internet-auctions have been growing rapidly over the past two decades (Deloitte, 2016) and global art sales are estimated to have exceeded USD 63 billion in 2018 (Art Basel, 2018). The relevant academic literature in finance has focused on the risk-return relationship of art (Mei and Moses (2002), Renneboog and Spaenjers (2013), Korteweg, Kräussl, and Verwijmeren (2016), Lovo and Spaenjers (2018)), its financial and macro-economic market drivers such as equity market evolution and income inequality (Goetzmann, Renneboog, and Spaenjers (2011), sentiment and hypes (Pénasse, Renneboog, and Spaenjers (2014)), and whether behavioral anomalies such as anchoring (Beggs and Graddy (2009), Graddy *et al.* (2015)) appear in the art market.

To study the determinants of art prices, a hedonic pricing model is often used to generate an index which depicts the risk and return of (schools of) art. The typical determinants of prices for paintings in particular include the reputation of the artist (e.g. his/her importance in art history as measured by a word count in an art encyclopedia or more simply by an indicator variable), physical characteristics of the painting (size, medium, signature, and date), subject matter (e.g. urbanscape, portrait), and transaction characteristics (auction house, sale location, lot number, and

[1] The Guardian, 18 Nov. 2013. Mr. Hook is a board member and senior director at Sotheby's in London with more than 45 years' experience, and particular expertise in Impressionist & Modern Art market.

auction seasonality). As pointed out in the above quotation by Mr. Hook of Sotheby's, composition and color may induce a visceral emotional impact on buyers. Throughout art history, a debate on color versus design/drawing (*colore* versus *disegno*) has regularly resurfaced.[2] Although the use of color has been recognized as a key component of the aesthetic value of a painting, there has been almost no research on colors and their emotional effects in an art pricing framework. This motivates the research questions addressed in this study: (1) Do a painting's color attributes affect its price? (2) If color attributes do affect the price, is it because color attributes trigger certain quantifiable emotional impacts which are reflected in the price? (3) Does the potential price impact of color differ across cultures?

Color systems, and in particular the effect of color on emotional states, have been discussed since Aristotle and this debate has led to various theories of color developed by artists, philosophers, physicists, and psychologists (Silvestrini (1994)). Color has also been shown to affect decision making. One strand of literature documents the effects of various interior colors in department stores on consumer purchase intentions and buying behavior (Bellizzi and Hite (1992), Brengman (2002)).[3] A few studies find that priming financial decision makers with red stimuli (background, logo, or text) increases risk avoidance (Kliger and Gilad (2012), Chan and Park (2015), Gnambs, Appel, and Oeberst (2015), and Bazley, Cronqvist, and Mormann (2017)). Colors on objects are also found to affect non-financial decisions such as voting (ballot colors, Garrett and Brooks (1987)), food intake (package colors, Genschow, Reutner, and Wänke (2012)), and customized configurations (product colors, Deng, Hui, and Hutchinson (2010)).

In this paper, we report the results of (1) an empirical estimation of pricing models in art markets, and (2) an experimental study in which we study the relationship between colors, emotions, and the valuation of art in the laboratory. Our research proceeds in two stages. First,

[2] E.g., the Venetian versus Florentine schools in Renaissance Italy, Rubenists versus Poussinists in the Baroque, and impressionists versus the French Academy des Beaux Arts (neo-classicism) in the 19th century. For details on color theories and color systems: see Online Appendix I.

[3] The literature on emotions and decision making has extended into investor psychology and asset pricing. Two examples are the following. (i) Specific weather conditions drive investor moods, which affect trading behavior and asset returns (Kamstra, Kramer, and Levi (2003), Hirshleifer and Shumway (2003), Loughran and Schultz (2004), De Silva, Pownall, and Wolk (2012), Goetzmann and Zhu (2005), Goetzmann *et al.* (2014)), and (ii) euphoria following sports victories seems to be related to asset prices and returns (Edmans, Garcia, and Norli (2011), Bollen, Mao, and Zeng (2011), Palomino, Renneboog, and Zhang (2011), Garcia (2013)).

we gather a large sample of high-quality images of 12906 oil paintings, watercolors, and color drawings produced by artists belonging to art schools of Color Field, Washington Color School, Abstract Expressionism, Abstract Imagist, Post-painterly Abstraction, and Bauhaus, that were sold through auction houses around the world during the 1994-2017 period. As we focus on color only and seek to eliminate potential contamination effects induced by a painting's figurative or symbolic meaning, we exclude paintings which contain figurative objects or abstract constructs (such as geometric patterns) or have non-rectangular shapes (e.g. diamond, round, oval, etc.). The retention decisions require consensus by at least three judges. We also exclude images corresponding to bought-in or withdrawn lots. This process resulted in 5482 images of non-figurative abstract paintings. We then study whether specific colors, color combinations, and the locations of colors on a painting's surface affect a painting's value, while controlling for many hedonic variables.

Second, in order to explain the relationships we find between color and prices, we develop a laboratory experiment to measure the emotions triggered by experiencing color in paintings (using the PA(D) approach, Panel A of Online Appendix II) and to examine which emotions relate to purchase intentions, rankings (Panel B of Online Appendix II), and auction bids (using the BDM approach, see infra). The experiment enables us to vary the three dimensions of color, namely hue, saturation, and luminosity, ceteris paribus. It also enables us to observe and relate color preferences, emotions, painting' rankings, purchase intentions, and willingness-to-pay for paintings at the individual subject level. As the emotional impact of color may be sensitive to culture, we perform our lab experiments with Chinese, European, and American participants, in Shanghai (China), Tilburg (the Netherlands), and Tucson (USA), respectively.

Our large sample hedonic pricing model reveals that a one standard deviation increase in the percentage of blue (red) hue in a painting leads to a significant premium of about 10.63% (4.20%), which is about USD 53,612 (21,183) more than the average price of an auctioned painting of the above schools of art. Second, the color combination of red-blue (followed by green-blue, and yellow-blue) trade at the highest premiums. Third, the dispersion of colors across the painting's surface does not in general affect the painting's valuation, with exception of color in the golden ratio areas. These areas on the painting are most salient, and here a small increase of 0.8

percentage point[4] of blue hue is related to premiums from 3.81% to 6.69%. Fourth, incorporating color attributes into a traditional hedonic pricing model increases the R^2 from 72.4% to 85.4%. The extra explanatory power is mainly contributed by variables capturing hue percentages rather than the degrees of saturation and luminosity.

Our laboratory experiments also yield consistent results. First, we find that single-color non-figurative abstract paintings (in the style of Mark Rothko) of blue and red hues carry significant value premiums of 18.57% and 17.28%, respectively, compared to the average willingness-to-pay. A non-monetary preference ranking and a purchase intention measurement yield the same preferences for blue and red over other colors. We thus observe a color-bidding hierarchy which puts blue and red on top, followed by green and purple, and with orange and yellow at the bottom. Saturation and luminosity variations do not affect the valuation ranking, which suggests that the hue dimension of color has a dominating impact. Second, the color hierarchy is largely the same for Chinese, European, and American participants. This pattern suggests that the preference for blue and red that we detect in the art auction data set is robust and may be universal. Third, we find that colors induce different emotions, as measured with the Pleasure-Arousal (PA) framework. The hues of blue and green are viewed as more pleasurable, and the hues red, green, and purple lead to more arousal, relative to the benchmark hue (yellow). Fourth, the pleasure emotion induced by viewing a painting serves as the main channel that relates colors to the monetary valuation. In contrast, the arousal emotion does not affect the valuation of paintings, with the exception of a trivial impact on purchase intention. Fifth, for two-color combination paintings (dual color Mark Rothkos), the bid price is strongly correlated with the average bid price of the constituent colors in single-color paintings. Again, blue and red, this time combined, receive the highest bids among all two-color combinations. The emotion of pleasure is highly correlated with the prices for dual-color abstract art. Sixth, all of the above results remain valid and are consistent when controlling for the weather conditions at the time of the experiment, the participants' gender, educational background, wealth, weather-induced mood, art exposure and education, cognitive

[4] Each of the golden ratio areas covers 4% of the painting surface and one standard deviation of the percentage blue is about 20% of the surface within a gold ratio area. Therefore, a one standard deviation increase of blue for a gold ratio area is 0.8% (=20%*4%) of the surface of the entire painting.

ability and color vision, and when we replace the participants' characteristics by subject fixed effects.

We contribute to the literature in three ways. First, we add an important set of hedonic variables to art auction pricing models. Second, we contribute to the growing literature of the roles of emotions in decision making, by clarifying the connection between colors and emotional states, as well as between emotional states and willingness-to-pay. Third, we add to the literature on cultural economics in that we reveal the important role of color in art prices and in the desirability of art works. We also show that the bidding preference for colors does not depend on the cultural background of the buyer, at least for the type of abstract art that we consider.

The paper proceeds as following. Section 2 describes the hedonic pricing methodology, the experimental design, and the data. Sections 3 and 4 present the empirical results from the auction data analysis and the laboratory experiments, respectively. Section 5 concludes.

2. Methodology, Experimental Design, and Data

2.1 Large Sample Analysis

2.1.1 Color and Valuation

From the Blouin database, we collected a large sample of high-quality images and transaction records of paintings auctioned during the 1994-2017 period in auction houses around the world.[5] We included oil paintings, watercolors, and colored drawings in our sample, and filtered out prints and collages. As we are primarily interested in the role of color on auction prices, we focus on six art schools in which color and color combinations are the essential, if not the dominant, elements. These schools are Color Field, Washington Color School, Abstract Expressionism, Abstract Imagist, Post-painterly Abstraction, and Bauhaus. We identified more than one hundred artists from exogenous art history sources (e.g. Oxford Grove Art Online) and collected all available auction records related to these artists as well as the corresponding images of their auctioned work. We obtained 12906 records with painting images.

We have addressed several potential sources of distraction from the pure color effects. First,

[5] Our earliest observations are in the year 1994, as digitalized images of paintings auctioned prior to 1994 are not available in the database.

as painters are usually active in multiple artistic styles (or have early work before they establish their "own style"), they may have made figurative work, which we exclude. Second, we also exclude paintings with patterns, such as geometric structures or symbols as they may induce meaning (beyond color). Third, less traditional shapes of paintings (e.g. oval, round, or diamond-shape) may also distract the viewer, which is why we only retain the most common, rectangular shape. In order to eliminate paintings that may be subject to the above contagion problems, we and several research assistants individually eyeballed all the 12906 images and removed any paintings where one of the above mentioned issues could be a concern. A painting is only included in our sample when all (at least three) viewers reached consensus, and the quality of the image is high enough for a color analysis at the pixel level. Furthermore, we only retain the auctioned paintings and exclude the ones bought-in or withdrawn. Our final sample comprises 5482 paintings by 66 artists.

In order to study the price impact of colors on prices, we estimate hedonic pricing models. We take the natural logarithm of real USD hammer prices[6] as the dependent variable and use various color measures as explanatory variables, while controlling for a wide range of hedonic characteristics. Our specification is:

$$\ln(Price_{kt}) = \alpha + \sum_{m=1}^{M} \beta_m \, Artist_{mkt} + \sum_{n=1}^{N} \beta_n \, Transaction_{nkt} + \sum_{p=1}^{P} \beta_p \, Physical_{pkt} + \sum_{q=1}^{Q} \beta_q \, Provenance_{qkt} + \sum_{z=1}^{Z} \beta_z \, Color_{zkt} + \varepsilon_{kt} \quad (1)$$

where $Price_{kt}$ represents the hammer price of art object k at time t, $Artist_{mkt}$ is an artist-specific attribute m of item k at time t, $Transaction_{nkt}$ is transaction-level attribute n, $Physical_{pkt}$ is physical attribute p, $Provenance_{qkt}$ is a provenance-related attribute q, and $Color_{zkt}$ is color attribute z. The coefficients β reflects the relative shadow prices of the corresponding characteristics. Thus, this model accounts for a set of attributes related to artist, transaction, physical art object, provenance information, and color.

[6] The Blouin database gives either the hammer prices or the premium price, which is the hammer price plus a commission averaging 15%, paid by the buyer. Given that the actual percentage of the commission is not available, we divide the premium price by 1.15 as an approximation of the hammer price.

First, the set of $Artist_{mkt}$ variables comprises:

1. *Artist dummies.* We include artist fixed effects to account for artists' reputation and other personal traits.

2. *Deceased artist dummy.* This dummy equals one for sales after the artist's death, as it is often assumed that prices for art works increase after the artist's death.

3. *Attribution dummy*. As attribution uncertainty can be an important factor discounting the price of art objects (especially of older works), we generate a dummy variable that captures doubts about the identity of the creator of the painting.[7]

Second, we include the dummy variables $Transaction_{nkt}$ that stand for transaction level attributes such as the timing of the sale, and the reputation and location of the auction house:

1. *Month dummies*. Important sales are often clustered in time, and the busiest months are May/June and November/December. January is omitted and serves as benchmark.

2. *Year dummies*. We include year fixed effects and the exponential of the coefficient of each year's fixed effect yields an index number for the corresponding year. Therefore, we can calculate index returns based on the index series.

3. *Auction house dummies*. We introduce auction house fixed effects for every auction house at the branch level. We distinguish among the different fine art auction houses based on reputation. For Sotheby's and Christie's, we introduce dummy variables for their London, New York, and other sales rooms (e.g., Soth_London, Soth_NYC, and Soth_Other). Together, these two institutions account for more than 60% of all sales in our sample. For two other big British auction houses, Bonhams and Phillips, we make a similar distinction among their London, New York, and other sales rooms (See Panel A of Appendix I). We also report the effect of selected smaller auction houses in our analysis.

Third, we include a vector of price-determining variables ($Physical_{pkt}$) capturing the physical characteristics of the painting. We use variables that capture the medium, size, and authenticity of the work of art:

[7] Different levels of attribution are used in the art auction world: attributed to, studio of, circle of, school of, after, and in the style or manner of.

1. *Medium dummies*. We introduce dummies for Oil paintings, Watercolors (including gouaches), and Drawings.

2. *Size*. The height and width in centimeters are represented by Height and Width and their quadratic forms.

3. *Authenticity dummy*. The dummy equals one if the auctioned lot contains any of the physically identifiable markings - signature, date, or inscription - that confirm the authenticity of the art piece.

Fourth, we include a set of variables $Provenance_{qkt}$ containing provenance information offered in the auction catalogue.

1. *Provenance dummy*. This dummy equals one if there is textual information in the catalogue about the provenance (past ownership, previous sales information, etc.) of the auctioned lot.

2. *Literature dummy*. This dummy equals one if there is textual information in the catalogue about the literature coverage of the auctioned lot. Art-related literature include scholarly articles, art critics, art catalogues, *catalogue raisonné*, etc.

3. *Exhibition dummy*. This dummy equals one if there is textual information in the catalogue about the exhibition history of the auctioned lot.

Fifth, we introduce a set of color-related variables, $Color_{zkt}$, analyzed from high quality images of paintings at the pixel level, and we decompose colors according to the Hue-Saturation-Value method (HSV).[8] We classify these variables into color attributes and color controls.

1. *Color attributes*. These hue percentages are the key variables of interest: we assign the chromatic part of each pixel to one of six major hues according to the segments on the color wheel. We thereby obtain the percentages of Pct_Red, Pct_Orange, Pct_Yellow, Pct_Green, Pct_Blue, and Pct_Purple of the whole painting.

2. *Color controls*. We count the number of hues whose percentages exceed a 3% surface coverage threshold. We also calculate the average and the standard deviation of saturation and luminosity in the colored part of the painting. Furthermore, we calculate the achromatic black

[8] Saturation is often referred as chroma or intensity, and value is often referred as lightness, brightness, or luminosity in daily use and other color models. For consistency, we only use saturation and luminosity in this paper except for specific color models (e.g. HSV color model – See Online Appendix I).

percentage of the whole painting, as well as the percentage that is white (which is omitted as the benchmark).

2.1.2 Color and Returns

We construct two color return series based on (i) index returns and (ii) repeat sales returns. For the index return method, we first run the traditional hedonic regression, which is essentially equation (1) without the color attributes. This is our benchmark regression and we calculate the exponential of the coefficient of year fixed effects to obtain the index series, which enables us to calculate art returns. Then we add, one by one, the six Hue Percentages into the benchmark equation and calculate the exponential of the coefficient of year fixed effects as the new art index series. For instance, for the hue red, we estimate the model:

$$\ln(Price_{kt}) = \alpha + \sum_{m=1}^{M} \beta_m \, Artist_{mkt} + \sum_{n=1}^{N} \beta_n \, Transaction_{nkt} + \sum_{p=1}^{P} \beta_p \, Physical_{pkt} + \sum_{q=1}^{Q} \beta_q \, Provenance_{qkt} + \beta_{red} \, Pct_{red,kt} + \varepsilon_{kt} \quad (2)$$

The difference between the index series derived from the year fixed effects of equation (2) and the index series derived from the traditional hedonics model without any color variables, is the index series of the Hue Red.[9] In this example, the Hue Red index series enables us to calculate the Hue Red returns.

To obtain the repeat sales returns, we first identify pairs of repeat sales within our sample. We select repeat sales candidates for each artist based on the exact title and on similar height and width (a 10% discrepancy is allowed as measurement could have been done with and without including the frame). We then view the digitalized pictures of all candidate pairs to rule out false pairs. We calculate the returns based on hammer prices in USD from two adjacent auctions of the same painting. The repeat sales period is the number of calendar days between two auctions. We calculate the normalized returns as the geometric return in this period as

[9] We set the first year in our sample as the starting point (100) and the corresponding hue index series is then 100 plus the difference between the two art index series.

$$\text{Normalized Return}_{k,t} = \sqrt[\frac{365}{repeat\ sales\ period}]{\frac{Hammer\ Price_t}{Hammer\ Price_{t-1}}} - 1 \qquad (3)$$

Similarly to equation (1), we regress the normalized return on a comprehensive set of hedonics including color attributes:

$$\begin{aligned}\text{Normalized Return}_{k,t} = \alpha + \sum_{m=1}^{M} \beta_m\, Artist_{mkt} + \sum_{n=1}^{N} \beta_n\, Transaction_{nkt} + \\ + \sum_{p=1}^{P} \beta_p\, Physical_{pkt} + \sum_{q=1}^{Q} \beta_q\, Provenance_{qkt} + \\ + \sum_{z=1}^{Z} \beta_z\, Color_{zkt} + Repeat\ Sales\ Period_{kt} + \varepsilon_{kt} \qquad (4)\end{aligned}$$

2.2 Experimental Design

2.2.1 General Procedures

The experiments took place at three universities in three different countries: China, the Netherlands, and the United States. We conducted 14 experimental sessions at the Finance Lab at Shanghai University of Finance and Economics (China) with a total of 166 Chinese participants. Sixteen sessions were performed at the CentERlab at Tilburg University (the Netherlands) with 185 subjects. In this group, roughly half of the participants were Dutch and the other half were from other European countries (non-European participants were excluded). Another 15 sessions were conducted at the Economic Science Laboratory at the University of Arizona (Tucson, U.S.A.) with 132 US students taking part (Online Appendix III). All participants were university students who were enrolled in the local recruiting system for laboratory experiments and were aged between 18 and 28. Each person was allowed to participate in only one session. All sessions were conducted by the same experimenter in all three locations.

Each location was equipped with large computer screen monitors, which were calibrated so that they displayed equal brightness, saturation, and contrast across locations. The monitor vertical angle and position on the desk were also adjusted to be the same. Light conditions, lab layout, and lab decorations were also standardized across locations such that there was no eye-catching color inside the labs or in the corridors leading to the labs. The experimenter wore glasses

with dark frames, a grey shirt, dark blue jeans, and white shoes in all sessions. The sessions were conducted in Chinese in Shanghai, and the Tilburg and Tucson sessions were in English. The interface was developed and shown in Z-tree 3.4.7 (Fischbacher (2007)), and the default background color of the screen was neutral grey.

In the experiment, we elicited participants' preferences for the different paintings by means of various measures (see below). Participants were clearly informed that they would see pictures of high quality prints on the experiment interface and that they would bid on the physical prints.[10] At the beginning of the session, the participants took part in three training rounds to familiarize themselves with the BDM auction method (Becker, DeGroot, and Marschak (1964)),[11] which we used to elicit their valuations for the paintings. The participants were aware that the practice rounds would not count towards their payment. Each session consisted of three training rounds, as well as two rounds (consisting of the evaluation of 6 paintings in each round) that could count toward the participants' earnings. The numbers of rounds and of pictures to be shown were not revealed to the participants beforehand. Each round consisted of viewing and evaluating a set of paintings. An evaluation consisted of (1) reporting one's emotions after viewing each painting, (2) indicating one's purchase intention for a large print of the painting shown on the screen, (3) ranking the set of paintings from the same round from most to least preferred, and (4) bidding between 0 and 100 ECU on each painting shown. Bidding zero was allowed and indicated that the participant had no interest in buying the corresponding painting.

Each participant's endowment was set at 100 ECU and he/she could bid from 0 to 100 ECU on every painting. At the end of the experiment, one bid out of all 12 bids was randomly selected to count for each individual participant. The random selection was revealed to the participant and compared to a randomly generated selling price.[12] This procedure was exactly the same as the one

[10] Bushong, King, Camerer, and Rangel (2010) use the BDM method to elicit willingness-to-pay in three different display settings (namely text display, image display, and physical goods display) and find that the average willingness-to-pays differs significantly in different display settings. In our experiment instruction and training rounds, we ensure that the participants are aware that they will bid on a high-quality physical print, which they will receive at the end of their session in the event that their bid is accepted.

[11] Miller *et al.* (2011) compare four common measurements to elicit consumers' willingness to pay (open-ended questions; choice-based conjoint analysis; BDM incentive-compatible mechanism; and incentive-aligned choice-based conjoint analysis) with real purchase data; BDM method yields the closest willingness-to-pay to the real purchase data.

[12] Under the BDM procedure, bidding one's true willingness to pay is optimal, by the same logic as bidding one's value is a dominant strategy in a second price sealed bid auction. Bidding lower than one's valuation reduces the

used to determine the hypothetical earnings in the three training rounds. The participant had a winning bid if her bid was no less than the randomly generated selling price. If the individual won an item, she paid the selling price (deducted from the 100 ECU endowment) and received a high quality physical print of A3 size of the corresponding auctioned painting, immediately after the experiment. The remainder of the initial monetary endowment was converted to and paid out in local currency at the exchange rate indicated above. If the bid was lower than the randomly generated selling price, the participant did not receive the print of the corresponding painting auctioned and received instead the entire initial endowment of 100 ECU, converted to and paid out in local currency at the above exchange rate. Participants did not know which one of the bids would count and how much would be her (individually) randomly generated selling price until the end of the session.

2.2.2. Timing of activity in each session

A session proceeded in the following manner. The experimenter read the instructions aloud to all participants (Online Appendix IV). The participants were then informed that they were endowed with 100 Experimental Currency Units (ECU). The exchange rates from ECU to local currencies were set to equal about two lunch meals in campus student restaurant: ECU 100 ECU equaled CNY 25, EUR 10, and USD 16, respectively. We used different methods across the locations to pay the participants after the experiment: Wechat Pay in China, bank transfer in the Netherlands, and cash in U.S.A.

After reading the instructions to the participants, the experimenter started the program for each individual. In the training rounds, only pictures of emotionally neutral items[13] were shown on the screen. Each picture of a painting was shown for 10 seconds and the participants were then asked to report the emotional states induced by this painting. They did so on scales constructed

probability of winning the item at a profit and confers no benefit, over bidding one's valuation. Bidding in excess of one's valuation induces a positive probability of paying more than one's valuation for the item, and also brings no benefit relative to truthful bidding. Techniques on implementation of the BDM mechanism have been studied extensively in experimental economics (Noussair et al., 2004; Cason and Plott, 2014). To generate our selling prices, we used a triangular distribution with lower limit 0, mode 20, and upper limit 100.

[13] We carefully selected emotionally neutral items based on a pilot experiment to avoid the priming of emotions at the beginning of experiment.

on a four-item short version of a PA(D) scale.[14] The pairs of antonyms used to capture emotions are measured on a seven-point scale and they are Happy-Unhappy (Pleasure 1, P1), Pleased-Annoyed (Pleasure 2, P2), Stimulated-Relaxed (Arousal 1, A1), and Excited-Calm (Arousal 2, A2) (see Panel A of Online Appendix II for more detail). The sequence of these four items was randomized by painting. A gradation of seven points was placed between each pair of antonyms; a score of 7 (1) indicates that the participant feels very happy (unhappy), pleased (annoyed), stimulated (relaxed), or excited (calm), respectively.

Subsequently, the participants rated their purchase intention by responding to four questions by means of a scale from 1 to 7 (strongly disagree to strongly agree): "I would love to buy this painting." (PI1), "I may spend more than intended on buying this painting." (PI2), "I would like to buy this painting immediately." (PI3), and "I regard the purchase of this painting as a waste of money." (PI4) (Panel B of Online Appendix II). The score on question PI4 was reversed and subsequently the average of the four scores was calculated and taken as the measure of purchase intention.

Six paintings were viewed and evaluated in each round. The paintings differed from each other only in their color scheme. Participants were then asked to rank all six paintings, which appeared simultaneously on the screen. No.1 stands for the most favored painting and No.6 indicates the least favored. We allowed for tied ranking of multiple paintings. For example, one could rank both the red and blue painting to be No.1 (the most favored). In the regression analysis, the Rank variable will be reversed so that a higher rating represents a higher place in the hierarchy.

The BDM bidding process described above was then implemented. In the training rounds, participants were asked to bid on emotionally neutral items. In the rounds that could count toward participants' earnings, the first 6 paintings auctioned were single-color paintings by Mark Rothko. We created six hue variations of this painting, and did not include the original black Rothko painting in the experiment. The next six paintings were transformations of a dual-color Mark Rothko work. We created 6 dual-color combinations of that painting and did not use the original

[14] The dominance dimension was not used for two reasons. First, when compared to pleasure and arousal, the dominance dimension has only very limited power in explaining the variance of emotional reactions to environmental situations (Mehrabian and Russell (1974)). Second, the hue-dominance relation is weak and statistically insignificant (Valdez and Mehrabian (1994)).

in the experiment. The six paintings within each round were displayed in a sequence randomized at the level of the participant.

At the end of the session, the participants filled out an exit questionnaire (Online Appendix V) on personal information (gender, year of birth, nationality, education level, current study program), art background (preference for specific visual arts, favorite art genre, frequency of attending art-related activities, art-related education, number of paintings at the home the participant grew up, and whether a participant recognized any artists from a list of twenty artists),[15] color-related specific information (awareness of color blindness, and preference ratings of hues), financial situation (part-time job alongside studies, income per month, expenditure per month, and student loan amount), and some other control variables (related to whether or not they liked the weather that day, a cognitive reflection test (CRT, Frederick (2005)), and a color vision deficiency test. We excluded color-deficient participants from our experiment's analysis.

The preference rating of hues was conducted as follows: the participants gave a rating (strongly dislike, dislike, neutral, like, to strongly like) for the six major hues (red, orange, yellow, green, blue, and purple) as well as for three achromatic colors (white, black, and grey). A score from 1 to 5 was given with the higher number representing a greater preference for a hue. We also collected the weather information for the hour that the experimental session started, because several studies have shown that the weather can influence decision making at the individual and institutional level (De Silva, Pownall, and Wolk (2012), Goetzmann *et al.* (2014)). The weather information includes temperature, humidity, air pressure, cloud coverage (clear sky, scattered clouds, partly cloudy, mostly cloudy, overcast, or mist), and precipitation, which was also verified by the experimenter on site. We chose the nearest weather station to each laboratory and this distance was always less than 15 km. The experimenter also recorded whether it rained shortly before each session.

2.2.3. The stimuli

The modification of colors of the original single- and dual-color paintings (namely, the hue,

[15] The list comprises Paul Cézanne, Pieter Breughel, Damien Hirst, Jeff Koons, Marc Chagall, Henri Matisse, Joan Miro, Claude Monet, Mark Rothko, Ton Schulten, Pablo Picasso, Peter-Paul Rubens, Piet Mondriaan, Alberto Giacometti, Andy Warhol, Rembrandt Harmenszoon van Rijn, Vincent van Gogh, Pierre-August Renoir, Alfred Sisley, and Winslow Homer.

saturation, and luminosity) was performed using Matlab. We adopted the widely-used Munsell color system and used the HSV model to analyze high resolution pictures of the original paintings at the pixel level. Hence, for each pixel we considered three parameters corresponding to the pure color (hue), the saturation, and the luminosity. Saturation is higher when less neutral grey is added to the pure color, and a higher luminosity means that more pure white is added. We took the hues at 0, 30, 60, 120, 240, and 300 out of 360 degrees of the color wheel. These points represent the classic red, orange, yellow, green, blue, and purple, respectively.

As we also sought to examine whether it may not just be the hue that affects the evaluation of art but also the color dimensions saturation and luminosity, we adjusted the saturation and luminosity of the six colors and created the following saturation-luminosity combinations: High-High, High-Low, Low-High, and Low-Low. A high saturation is defined as 7 out of 10, and low saturation as 3 out of 10; a high (low) luminosity is defined as 8 (5). For the experiment, we ignored the Low-Low group because the images become very dark and it is then difficult for the human eye to discern the hue variations. As a consequence, we have six major hues with three combinations of saturation and luminosity for our experiment.

For dual-color Mark Rothko abstract art, we rotated the original picture to be left-right positioned and made the color segments equal in size in order to eliminate potential concerns of a color weight effect when two color segments were positioned up and down, and to cancel the area size effect of a hue.[16] To prevent the task from becoming too repetitive, we limited the number of paintings shown to the participants and showed six dual-color pictures arising from combinations of the four primary hues (red, yellow, green, and blue). We also applied the same method of hue, saturation, and luminosity modification that we used for the single-color art on both the left and right panels of the dual-color art. This resulted in red-yellow, red-green, red-blue, yellow-green, yellow-blue, and green-blue dual-color paintings, each of which were modified according to High-High, Low-High, and High-Low luminosity-saturation combinations. The position of a constituent hue on the left or the right panel was randomized and then fixed across

[16] A painting with a red half on top and a green half on the bottom appears visually different from the opposite combination. An average person would perceive red bottom as heavier. Furthermore, a green lower part combined with a blue upper part could be interpreted as landscape with blue sky over a green meadow.

all sessions. Our modified paintings preserved the specific brush strokes and texture of the original.

Each participant only saw the paintings in a fixed setting of saturation-luminosity combinations, so that we had a within-subject analysis of the hue effect and a between-subject analysis of saturation-luminosity effects. As a robustness check, we asked about half of the Tilburg and Tucson participants to rate the single-color Rothko abstract art in three saturation-luminosity settings of six hues as a within-subject analysis of saturation-luminosity effects.

3. Results from Large Sample Auction Data

3.1 Descriptive Statistics

We have obtained 5,482 abstract non-figurative paintings sold in auctions for which high quality images are available. The average hammer price is USD 504,349, the average height and width are both close to 96 centimeters. 81% of the paintings are oil paintings, 18% are watercolors (including gouaches), and 1% are colored drawings (Table I). More than 60% of the paintings are auctioned by one of Sotheby's or Christie's branches. 89% of the paintings in our sample carry a signature, date, or inscription authenticity marking, and in less than 1% there may be some doubt about authenticity as these paintings are attributed to specific artists. 54% of paintings have clear provenance information including past ownership, previous sales history, etc. 19% of paintings have been shown in exhibitions before their sale, and 12% have been covered in the literature (in scholarly articles, art critics, art catalogues, etc.). In terms of color attributes, on average 19% of the painting surface is red, 10% is orange, 15% is yellow, 7% is green, 14% is blue, and 2% is purple. The average saturation and luminosity are 0.43 and 0.64, respectively, and the average number of chromatic hues used in a painting is close to three. To proxy for the degree of scattering of a hue in the painting, we calculate a dispersion factor. The normalized dispersion of a specific hue is based on a pixel analysis. Dispersion is the average Euclidean distance of each (e.g. blue) pixel to the center pixel among the blue hues in the painting image, normalized by the painting's diagonal pixel length. Therefore, the larger the dispersion factor, the more scattered the dots of blue hues in a painting are. The average dispersion for each chromatic hue is quite homogenous at around 20%. Detailed definitions of all variables are given in Panel A of Appendix I.

[Insert Table I about here]

3.2 Regression Results

3.2.1 Hue Percentage and Valuation

We regress the natural logarithm of the hammer price in USD on the percentages of chromatic hues in the corresponding paintings. We set the percentage of white as the benchmark and add in controls for color, size, medium, authenticity, provenance, and artist death (Models 1-6 of Table II). All models include artist, year, month, and auction branch fixed effects and the standard errors are clustered at the auction branch level. Model 4 is our focal specification which shows strong evidence that a higher percentage of blue or red in the painting commands a higher premium in an auction. For a one standard deviation increase in the percentage of blue (20%) or red hue (22%), the value premiums are 10.63% and 4.20%, respectively.[17] For the average hammer price in our sample, this represents about USD 53,612 for blue and USD 21,183 for red, respectively. To address any potential concerns about whether our results are solely driven by single hue paintings, we split our sample into one group that contains paintings with only one chromatic hue, and another one that comprises paintings with multiple chromatic hues (Models 5 and 6). We find that the results are valid for both subsamples. For a single chromatic hue painting, a one standard deviation increase in the percentage of the surface area that is of blue or red hue (relative to benchmark white) will lead to premiums of 15.7% and 9.8%, respectively.[18]

[Insert Tables II and III about here]

3.2.2 Dual Color and Valuation

To study dual color combination effects, we follow the specification of model 4 of Table II

[17] This is calculated, e.g. in the blue hue case, as exp(0.505*0.20) – 1 = 10.63%.

[18] As robustness checks, we change the boundary parameters between neighboring 6 major hues on the color wheel; we exclude pixels in the boundary regions on the color wheel; and we reparametrize the orange and yellow hues since the white surfaces of a canvas/paper, whether left blank intentionally or painted white, have a tendency to become yellowish with aging. Our results remain qualitatively and quantitatively similar. In order to investigate the impact of the hue percentages and color controls on the explanatory power of the pricing model, we run two additional (unreported) regressions based on Model 4 and exclude, respectively, (i) the hue percentages and (ii) both the hue percentages and color controls. The R^2 is 85.4% in Model 4 and drops to 72.4% when excluding hue percentages and to 72.0% after excluding both hue percentages and color controls. This indicates that hue percentages are indeed important contributors to the explanatory power of the hedonic pricing model while the average value of saturation and luminosity, as key members in color controls, have little impact.

and use the percentage of a specific dual-color, the summation of the percentages from dual combinations of the four primary hues (red, yellow, green, and blue), as the dependent variable. Panels A and B of Table III report the respective results of two subsamples comprising paintings with: (i) only two chromatic hues, and (ii) more than two chromatic hues. The column header indicates the constituent hues in the dual-combination and the benchmark is the sum of all other hues and thus varies by model. The estimates show that the percentages of dual-colors of red-blue, green-blue, and yellow-blue induce a significant premium compared to their corresponding benchmarks. We can thus infer that blue in combination with other primary hues is value-adding.

3.2.3 Hue Dispersion, Salient Area, and Valuation

The two preceding subsections reported that the percentages of blue and red hues in a painting are related to higher values. Follow-up questions that we investigate here are: (i) Do particular shapes or patterns of colors affect paintings' prices? (ii) Are there any particular blue and red locations on a painting that trigger higher premiums?

To answer the first question, we introduce a normalized dispersion measure for each hue, which is greater when the hue is more dispersed over the painting's surface. This normalized dispersion factor is the average Euclidean distance between each pixel of a specific hue to the center pixel of that hue in the painting, which is normalized by the diagonal pixel length of the painting image. We regress the logarithm of hammer price in USD on the percentages of six major hues and their dispersion factors, and split the sample into single and multiple chromatic hue subsamples (Models 1-3 of Table IV). We find that the blue and red premium effects still hold in these models while the dispersion generally is not significant for orange, blue, and purple. For red, a more clustered shape is value-adding in the single chromatic hue painting while the scattering of the red hue is insignificant in multiple chromatic hue paintings.[19] For yellow and green, it is preferable for the hue to be dispersed across the painting.

In order to determine a salient area for the hues, we have tried different segmentations of the paintings' surfaces and associated the value of the paintings with the color attributes within those

[19] Note that a single chromatic hue painting may also contain black and white.

specific areas. We have considered 2x2, 3x3, or 4x4 equal cuts of the paintings and hence 4, 9, or 16 areas (or mini-paintings). We then regressed the painting valuation on the color attributes within each of the mini-paintings or some combinations of the mini- paintings with the same specification as Model 4 of Table II. However, we cannot identify consistent results from these mini-paintings.

As the golden ratio (1.618) is aesthetically important in figurative painting, architecture, and nature (Livio (2008)), we conjecture that the golden ratio may also play this role in non-figurative abstract art. We mark the two golden ratio points on each of the four outlines of the painting and then link them by drawing two horizontal and two vertical lines. The four interception points are defined as the golden ratio points.[20] We then focus on four small squares centered at these golden ratio points in the same aspect ratio of the original painting; each of them covers a surface of 4% of the painting. Table V reports the regression results of the log hammer prices in USD on the hue percentages in the four golden ratio areas. We find consistent and strong evidence that the presence of blue in these small golden ratio areas leads to a significant premium. An increase of 20 percentage points of blue hue within one of these small golden ratio areas (which is only a 0.8 percentage point increase for the whole painting; 20%*4%), still induces a significant premium of between 3.81% and 6.69% (depending on the golden ratio square). On average, a blue dot in a golden ratio area has 10 times the impact relative of a blue dot in a random area. Among the four golden ratio squares, the right-top one carries the highest premium.

[Insert Tables IV and V about here]

3.2.4 Hue and Return

One potential concern for the positive effects of blue and red on prices is that a high valuation may negatively affect future return. We identify 63 pairs of repeat sales[21] and regress their normalized return on a comprehensive set of hedonic variables. We find little evidence of a relation between hues and returns (with one – statistically rather weak - exception that yellow

[20] If we denote the width and height of the painting as W and H respectively and set the left-lower corner of the painting as the origin (0,0), the coordinates of the four golden ratio points are: Left-Top (0.382W, 0.618H); Right-Top (0.618W, 0.618H); Left-Bottom (0.382W, 0.382H); and Right-Bottom (0.618W, 0.382H).

[21] About 2% of our total sold observations are repeat sales. This is consistent with Renneboog and Spaenjers (2013).

lowers returns). The reason for this lack of relation may very well be the tiny subsample of repeat sales.

4. Results from Laboratory Experiments

4.1 Descriptive Results on the Valuation of Single-Color Abstract Art

After excluding the participants with color vision deficiency, we examine the preferences of the participants in our experiments in China, the Netherlands, and the USA, respectively. The average bidding results for the six major hues show that in each of the three cultures, single-color abstract paintings in red and blue hues receive the highest valuation with an average of more than ECU 18 in China, 17 in the Netherlands, and 18 in the U.S. (Table VI). The green hue comes third with an average between ECU 14 to 17 in the three countries; the hues orange, purple, and yellow are in the least-valued group (between ECU 11 to16). We find it remarkable that this color-bidding hierarchy is similar across cultures.[22]

[Insert Table VI about here]

4.2 Regression Results

While the descriptive statistics show clear patterns in color premiums for blue and red, individual choices display considerable heterogeneity. We therefore regress the bids on colors while also controlling for either subject fixed effects or a broad set of control variables including personal traits and session characteristics. The definitions of all variables are given in Panel B of Appendix I.

4.2.1 Single Color and Valuation

We first regress the individual bids on the single-color paintings' hues (red, orange, green, blue, and purple whereby the omitted yellow serves as the benchmark) and include subject fixed

[22] We also study whether people bid according to their personal color preferences. The results are given in Online Appendices VI and VII. In Online Appendix VII, the horizontal axis indicates the six hues, the depth axis displays the rating of a given hue from 1 to 5, and the height of each bar represents the average valuation of the corresponding hue at a specific level of affect towards it. For example, the height of the red bar located at the crossing of "red" and "5" is the average bid on the red single-color abstract art by the individuals who rated red at "5" (a strong liking). The figure depicts a positive relationship between bid prices and preference towards a hue. The table also shows that the correlation between color preferences and bids is significantly positive and ranges between 15% and 24%, so that the analysis of the bids on the paintings does not just pick up color preferences.

effects (Model 1 of Table VII). A participant can only take part in one experimental session and will only view the hues in one of three saturation-luminosity combinations; the subject fixed effects are a strong control for any personal (and session) traits. We find that in all three locations, the hues blue and red always carry significant premiums. Red elicits bids by Chinese participants that are on average ECU 3.32 higher than yellow, and European (American) participants bid ECU 6.26 (4.59) more. Blue receives bids that are ECU 2.40, 5.91, and 6.97 higher in China, the Netherlands, and the U.S., respectively. Green also carries a significant positive premium in the Netherlands and the U.S. at ECU 2.80 and 2.91, respectively. Blue and red premiums are about 18.57% and 17.28% higher than the pooled average of all bids on the single color arts. In Models 2 and 3, the dependent variables are the Purchase Intention and the Rank of the paintings. Our results are largely consistent with those for bidding behavior: purchase intention and rank are higher for paintings that are blue and red.[23]

To study whether specific types of individuals value art differently, we replace the subject fixed effects with a long list of control variables capturing personal traits and session characteristics. We report, in Table VIII, that the results on color are upheld as blue and red carry a significant premium for all the three cultures. Also noteworthy is the impact of the two dummy variables HL and LH, which capture the High-Saturation-Low-Luminosity and Low-Saturation-High-Luminosity combinations, respectively (the omitted benchmark is HH). The HL and LH combinations are insignificant in all three different cultures suggesting that the hue-bidding hierarchy remains unchanged under different Saturation-Luminosity settings in a between-subject design.

[Insert Tables VII and VIII about here]

As a robustness test on the Saturation-Luminosity setting, we performed an additional within-subject experiment. We asked 118 and 65 participants in our European and American experiments,

[23] To alleviate concerns that the sequence in which the paintings were displayed may affect our results, we do a robustness check in Model 4 by including the sequence in which the six major hues were displayed as regressors (recall that the sequence was randomized at the individual level). We label the hues red, orange, yellow, green, blue, and purple as No.1, No.2,…, No. 6, respectively. The Order of Appearance in Model 4 represents the display order for a specific individual. For example, 2-1-6-4-3-5 means the display sequence orange, red, purple, green, yellow, and blue. The Order of Appearance-parameter estimates are insignificant, which indicates that the order of display does not affect valuation. Robustness tests on Purchase Intention and Rank yield similar insignificant results for the Order of Appearance.

respectively, to rate the three Saturation-Luminosity variations of six major hues of a single-color Mark Rothko in six additional experiment rounds. In each additional round, one painting in one hue but in three different Saturation-Luminosity variations was displayed on the same screen and positioned randomly on the left, middle, and right panel. Participants then rated these variations on a scale from 1 to 5 where 1 indicates a strong dislike and 5 a strong preference. A joint F-test on the average rating differences among Saturation-Luminosity variations within each hue does not indicate any statistically significant differences (in any of the locations) (Online Appendix VIII). As shown above, these rating comparisons are informative because rankings and ratings are strongly correlated to actual bidding results. Both our between-subject and within-subject analyses on the valuation/rating effects of Saturation-Luminosity combinations suggest that hue is the predominant characteristic affecting valuation.

Table VIII also shows that bidding is not affected by gender or age. The Cognitive Reflection Test Score has little impact; only European participants with higher cognitive scores are inclined to bid less. The weather conditions (as measured by the Temperature, Humidity, Air Pressure, Rain Before, and Cloud Coverage) do not significantly affect the participants' valuations. One (weak) exception is the rain that fell shortly before a session started in China, which seems to have negatively affected the willingness to pay, but this effect is only significant at the 10% level. The weather-induced mood is significantly positive for the Chinese and US experiments. Art Appreciation by a participant in China increases his/her valuation of single-color paintings, but we do not find an effect in the other locations. Similarly, Art Background does not affect bids.[24] The variables capturing whether the participant has a favorite type of art (such as Old Masters, or Modern & Contemporary, relative to No Preference) do not affect the valuation (with exception of the European participants whose favorite style is Modern & Contemporary art and who bid more for single-color abstract art - at a significance level of 10%).

We also control for the financial status of the participants by capturing whether or not they had a student loan, and their annual expenditure (sum of spending on accommodation,

[24] Art Background is a comprehensive index constructed by normalizing and equally weighting the responses to four questions about the frequency with which individuals attend cultural events, whether they have had an art-related education, training in painting, or grew up in a family with an artistic background (see Panel B of Appendix I).

transportation, food and drinks, tuition fee, and other expenses). We use reported expenditure rather than reported income, due to the concerns about misreporting of income and subsidies, and potential ambiguity about what constitutes one's own income and what is family aid. These expenditures do not explain the willingness to pay, with exception of the US participants, where wealthier individuals bid more on the art works.

4.2.2 Color and Emotion

To investigate the potential emotional channel relating color stimuli and art valuation, we first study whether the hues trigger specific emotions. We use the (dis)pleasure and (non)arousal dimensions to classify the main emotional states. Pleasure is calculated as the average response of scales of being happy/unhappy and pleased/annoyed. Arousal is calculated as the average on scales of being stimulated/relaxed and excited/calm. Each dimension ranges from 1 to 7, and a higher number stands for a stronger emotional state. We regress Pleasure and Arousal on hue fixed effects (yellow is the omitted benchmark) and include subject fixed effects (Table IX). Blue and green stand out significantly in terms of inducing pleasure (for Europe and the US), whereas orange is strongly negatively related to pleasure in each of the three locations. The response to red is not dissimilar from the response to yellow across all three locations. When we turn to arousal, we find that red, purple, and green are more effective in inducing arousal, whereas orange is more soothing (all relative to yellow). Blue is negatively correlated with arousal, but only significantly so in the US. Other than a few minor exceptions, Table IX shows similar patterns across the three locations/cultures.

[Insert about here Tables IX and X]

4.2.3 Emotions and Bidding Behavior

Art is usually considered as an emotional asset, which we confirm with this research relating color in abstract paintings to specific emotions. We have also documented above that a paintings' color affects consumers' willingness-to-pay. We now investigate which specific (color-induced) emotions play a role in the valuation and purchase process by regressing bid, purchase intention, and rank on the pleasure and arousal emotions in Table X. We find that the key emotional channel

(at a significance level of 1 %) relating color stimulus to valuation of single-color abstract art is pleasure. When a painting is making people happier, they are willing to pay more for it (Model 1), have a higher propensity to purchase it (Model 2), and they rank the painting more highly (Model 3). Increasing one notch on the pleasure scale results in a bid increase of ECU 4.63 in China, 6.24 in the Netherlands, and 5.30 in the U.S, which correspond to respective increases of 28.0%, 44.0% and 31.7%, respectively. In contrast, arousal has no significant impact on the bid and ranking of paintings (Models 1 and 3). The purchase intention increases slightly when people are feeling aroused, but the economic impact of arousal on purchase intention is small in magnitude (only 12% and 17% of the pleasure impact for the Netherlands and the US, respectively, in Model 2 of Table X) and Model 1 shows that arousal does not translate into actual purchase decisions. Our regressions control for subject fixed effects in all models.

All of our evidence suggests that pleasure is indeed the dominant emotional channel relating color stimulus to valuation. To investigate the robustness of the above findings, we adopt a two-stage model. In the untabulated first stage, we regress pleasure (and arousal) on the rating for the corresponding hue and, in the second stage, we regress the respective bid, purchase intentions, and rank on the predicted pleasure and predicted arousal, respectively (Online Appendix IX). Again, we find strong evidence (at the level of significance of 1%) that color-induced pleasure is the emotional channel leading to higher bid values, purchase intentions, and ranks.

4.3 Dual-Color Paintings and their Constituent Colors

4.3.1 Descriptive Statistics of Dual-color Abstract Art

In Table XI, we present the bidding results for the dual-color abstract paintings. The red-blue dual-color paintings attract the highest average bid of ECU 15.35, followed by an average bid of 13.43 for the green-blue combination. The least valued combination is red-green with a mean of only ECU 11.10. The average bid on all six dual-color abstract art paintings is ECU 12.93 (a discount of 18% compared to the average bid in the single-color round (15.71) with a standard deviation of 20.29.

[Insert about here Tables XI and XII]

4.3.2 Dual-color and Its Constituent Colors

We now turn to the relationship between the bids on dual-color works and single-color paintings of the same constituent colors. We find that the bid, purchase intention, and rank as well as the pleasure and arousal emotional states induced by the dual-color abstract art are all highly positively correlated with the average of the corresponding measurements of the single-color paintings with the constituent colors (at a 1 % significance level) (Panel A of Table XII) . The correlation amounts to 79% for the bids, 64% for the purchase intentions, and 37% for the ranking. The correlation coefficients for the emotional states induced by the combined colors and the average emotional states induced by the single constituent colors are approximately 50% (49% for Pleasure and 51% for Arousal). In Panel B, we report the regression results with the bids on dual-color paintings as the dependent variable and the average bid on the single-color paintings of the constituent colors as independent variables (Panel B of Table XII). As the average bid of certain constituent colors from the single-color round is given for an individual, we cannot include subject fixed effects. We do, however, include the comprehensive list of control variables used in Table VIII. We find that the bids on the color combinations are largely explained by the bids on the single colors: for example, 85% of the bid price variation in the red-blue combinations is explained by the average of the bids on red and blue. The explanatory power of the single colors amounts to between 69% and 85%.

To determine the color-bidding hierarchy, we regress bid, purchase intention, and rank on the dual-color combination fixed effects (whereby the least favored combination red-green is the omitted benchmark) and include subject fixed effects (Model 1 to Model 3 of Table XIII). We find that the combination of red-blue does indeed induce the highest bid premium, the strongest purchase intention, and the highest rank. The next favored color combination is blue-green. The difference in the bid between the least favored combination (RG) and the most favored one (RB) amounts to ECU 4.26, which is about one third increase of the average bid (ECU 12.93) on the dual-color painting. Green-glue, red-yellow, and yellow-blue dual-color abstract paintings carry significant premiums compared to red-green in all three measurements (bid, purchase intention, and rank). In terms of the emotional impact, red-blue and green-blue combinations significantly increase the pleasure level (at the 1% level of statistical significance), by 0.38 and 0.34 units,

respectively, relative to the baseline red-green (Models 4 and 5 of Table XIII). With regard to the arousal dimension, no other dual-color combinations attains a greater level of arousal than the baseline red-green combination.

[Insert about here Tables XIII and XIV]

4.3.3 Emotional Channels

We regress the three measures of preference: (1) bid, (2) purchase intention, and (3) rank, on our emotion measures in Models 1 to 3 of Table XIV. The estimates show that the reported pleasure is strongly positively related to bid prices, purchase intentions, and rank. As in the single-color analysis, arousal does not affect bid value and rank, though it has a statistically significant, but economically trivial, impact on purchase intention.

As a robustness check, we regress bid prices, purchase intention, and rank on the predicted emotions in a two-stage framework. In the first stage (untabulated), we regress pleasure (arousal) induced by dual-color paintings on the ratings for two constituent hues. In the second stage, we regress our three dependent variables on predicted pleasure and arousal while also including subject fixed effects (Online Appendix Table X). We confirm that the color-induced emotion of pleasure is the channel whereby color influences bids, ranks and purchase intention (at the level of significance of 1%). As before, arousal has no effect on the preference measures.

5. Conclusion

The psychological and aesthetic roles of colors in artwork have been discussed among psychologists, scientists, and painters for centuries, but the economic effects of colors have not been analyzed to date. This study attempts to isolate the effect of color on the value of paintings by means of both art auction data and laboratory experiments. In addition, the experiments enable us to investigate which emotional channels connect colors and a painting's auction value.

We find that color is indeed an important determinant of the market prices of paintings and their private valuations. We demonstrate that blue and red hues command significant premiums in the field and in the laboratory: in the auction prices of abstract paintings and their private valuations, as well as increase the purchase intention of paintings and their relative rankings. The

effects emerge for both single-color abstract paintings and dual-color abstract art, where the blue-red combination is valued the most among the color combinations we have studied. In terms of art returns, we find supportive evidence that blue leads to the highest return among the six primary hues. Of the three dimensions of color, it is the hue affects prices, bids, and purchase intention. Saturation and luminosity levels do not add much explanatory power to the hedonic regression model, nor do they affect the art valuation in the laboratory experiments.

By inquiring about the participants' emotional states after they have viewed a painting in a laboratory setting, we can measure the emotional response induced by a particular color in a painting. Among the basic emotional states (PA(D)), we confirm that the emotion of pleasure is strongly positively correlated to bid, amplifies the purchase intention, and leads to a higher ranking of a painting. The arousal level only affects the purchase intention and then only to a limited extent. Arousal does not translate to a higher or a lower bid. We find that the hues blue and green, as well as the dual-color combinations of red-blue and green-blue induce higher "pleasure". The valuations of dual-color abstract art, as well as the emotional states evoked by dual-color abstract art, are strongly and significantly correlated with the valuations and emotional states associated with the constituent single-color abstract art pieces.

All of the major results from our laboratory experiments are consistent across three locations, despite the different cultural backgrounds of participants. It is indeed remarkable that individuals from China, Europe, and the U.S. are all willing to offer higher bid premiums for blue and red colors. In view of the generality of these results, it is only natural that the premiums also appear in auction houses in different parts of the world.

This paper contributes to the literature in three principal ways. First, we verify and add the color dimensions of an artwork as an important missing class of variables to the hedonic pricing models in art auction markets. We confirm the importance and the consistency of the effects of hue in a large sample with both field and experimental data. Second, we contribute to the growing literature on the role of emotions in decision making, and provide another case showing the association between emotions and willingness-to-pay. Third, we provide the first cross cultural comparison of art preferences. The consistent patterns in the color-bidding hierarchy and in the emotional channel of decision making across three diverse cultures suggests that our results may

be universal.

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Table I Descriptive Statistics of Auctioned Paintings

This table reports descriptive statistics for hedonics used in the regression analysis. Detailed variable descriptions are provided in Panel A of Appendix I.

Variable	N	Mean	SD	P25	Median	P75
Hammer Price	5,482	504,349	3,269,296	10,326	30,000	130,000
Pct_Red	5,482	0.19	0.22	0.02	0.12	0.26
Pct_Orange	5,482	0.10	0.16	0.01	0.03	0.11
Pct_Yellow	5,482	0.15	0.20	0.01	0.07	0.19
Pct_Green	5,482	0.07	0.14	0.00	0.02	0.07
Pct_Blue	5,482	0.14	0.20	0.00	0.06	0.18
Pct_Purple	5,482	0.02	0.05	0.00	0.00	0.02
Pct_White	5,482	0.22	0.24	0.00	0.12	0.37
Pct_Black	5,482	0.11	0.19	0.00	0.04	0.18
Sat_Avg	5,482	0.43	0.19	0.29	0.41	0.56
Lum_Avg	5,482	0.64	0.16	0.53	0.65	0.75
Sat_Std	5,482	0.08	0.11	0.00	0.03	0.12
Lum_Std	5,482	0.08	0.10	0.00	0.04	0.11
Nbr_Hue	5,482	2.86	1.30	2.00	3.00	4.00
Disp_Red	5,482	0.22	0.09	0.18	0.24	0.28
Disp_Orange	5,482	0.23	0.09	0.19	0.25	0.29
Disp_Yellow	5,482	0.23	0.09	0.19	0.25	0.29
Disp_Green	5,482	0.19	0.11	0.12	0.21	0.27
Disp_Blue	5,482	0.19	0.11	0.10	0.22	0.27
Disp_Purple	5,482	0.16	0.11	0.02	0.19	0.26
Disp_Black	5,482	0.19	0.11	0.13	0.22	0.27
Disp_White	5,482	0.23	0.12	0.17	0.27	0.31
Height	5,482	96.1	65.7	45.7	76.2	127.0
Width	5,482	96.1	78.0	45.7	75.6	121.9
Oil	5,482	0.81	0.39	1	1	1
Watercolor	5,482	0.18	0.38	0	0	0
Drawing	5,482	0.01	0.12	0	0	0
Authenticity	5,482	0.89	0.32	1	1	1
Attributed	5,482	0.01	0.03	0	0	0
Literature	5,482	0.12	0.32	0	0	0
Exhibited	5,482	0.19	0.4	0	0	0
Provenance	5,482	0.54	0.5	0	1	1
Deceased	5,482	0.78	0.42	1	1	1
Soth_London	5,482	0.05	0.22	0	0	0
Soth_NYC	5,482	0.20	0.40	0	0	0
Soth_Other	5,482	0.03	0.16	0	0	0
Chr_London	5,482	0.05	0.22	0	0	0
Chr_NYC	5,482	0.23	0.42	0	0	0
Chr_Other	5,482	0.05	0.23	0	0	0
Bon_London	5,482	0.01	0.08	0	0	0
Bon_NYC	5,482	0.01	0.10	0	0	0
Bon_Other	5,482	0.03	0.17	0	0	0
Phi_London	5,482	0.00	0.07	0	0	0
Phi_NYC	5,482	0.01	0.11	0	0	0
Phi_Other	5,482	0.00	0.02	0	0	0

Table II Painting Valuation and Hue Percentage

Pct_Red, Pct_Orange, Pct_Yellow, Pct_Green, Pct_Blue, and Pct_Purple are the percentages of six major hues analyzed in the images of non-figurative abstract art works at the pixel level. Pct_White is omitted as the benchmark. Color controls are color-specific control variables consisting of: 1) the number of hues exceeding a 3% coverage threshold, 2) the average and the standard deviation of saturation and luminosity in the colored part of the painting, 3) the percentage of black hue in the painting. Size controls are width and height, and their quadratic forms. Medium controls include dummy variables for oil paintings and watercolors (the category of colored drawings is the benchmark). Authenticity controls comprise: 1) an authenticity dummy for whether a painting contains verifiable attributes (signature, date or inscription), 2) an attribution dummy for whether a painting is attributed to the artist, or produced in his studio, by his circle, or in the style of the artist or his school. Provenance controls are: 1) a provenance dummy for whether past ownership is documented in the catalogue, 2) an exhibition dummy for whether the art work has been exhibited in the past, 3) a literature dummy indicating if the art work has been covered in the art literature at the time of the sale. The deceased dummy equals one if auction took place after the artist had passed away. All models include artist, year, month, and auction branch fixed effects. The percentage of white hue is left out as the benchmark category. Models 5 and 6 are subsample analyses with the number of chromatic hues equaling one and greater than one, respectively. Panel A reports the coefficients of hue percentages. Panel B reports the coefficients of the month fixed effects, Panel C reports the coefficients of a selected number of prominent auction houses (with Clarke Auction, Larchmont as the benchmark), Panel D reports the coefficients of color, size, and medium controls, Panel E reports the coefficients of Authenticity, Attribution, Provenance, and Deceased controls. Panels B, C, D and E are based on Model 4 in Panel A. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors (S.E.) are reported in parentheses and clustered at the auction branch level.

Dependent Variable: Ln(Price)	Model 1	Model 2	Model 3	Model 4	Model 5 # of Hues =1	Model 6 # of Hues >1
Panel A: Hue Percentages						
Pct_Red	0.170**	0.169**	0.176**	0.187**	0.468**	0.163*
	(0.077)	(0.080)	(0.078)	(0.079)	(0.186)	(0.097)
Pct_Orange	-0.113	-0.105	-0.089	-0.098	0.408	-0.077
	(0.075)	(0.074)	(0.074)	(0.069)	(0.398)	(0.104)
Pct_Yellow	0.088	0.087	0.102	0.121	0.237	0.149*
	(0.079)	(0.079)	(0.078)	(0.078)	(0.187)	(0.078)
Pct_Green	0.110	0.101	0.113	0.130	0.242	0.185*
	(0.085)	(0.085)	(0.081)	(0.086)	(0.182)	(0.097)
Pct_Blue	0.483***	0.472***	0.496***	0.505***	0.731***	0.478***
	(0.103)	(0.103)	(0.093)	(0.093)	(0.220)	(0.097)
Pct_Purple	-0.283	-0.273	-0.261	-0.211	0.200	0.082
	(0.253)	(0.251)	(0.253)	(0.241)	(0.318)	(0.263)
Color Controls	YES	YES	YES	YES	YES	YES
Size Controls	YES	YES	YES	YES	YES	YES
Medium Controls		YES	YES	YES	YES	YES
Authenticity Controls			YES	YES	YES	YES
Provenance Controls				YES	YES	YES
Deceased Dummy				YES	YES	YES
Artist FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES
Auction Branch FE	YES	YES	YES	YES	YES	YES
Observations	5,482	5,482	5,482	5,482	821	4,507
R-squared	0.845	0.849	0.850	0.854	0.901	0.853

Panel B: Month Fixed Effects in Model 4							
January	[Left Out]	April	0.463***	July	0.222	October	0.382**
			(0.149)		(0.145)		(0.157)
February	0.397**	May	0.821***	August	-0.073	November	0.823***
	(0.154)		(0.159)		(0.320)		(0.163)
March	0.284**	June	0.432***	September	0.260*	December	0.476***
	(0.135)		(0.153)		(0.133)		(0.149)

Panel C: Selected Prominent Auction Branch Fixed Effects in Model 4							
Sotheby's, Hong Kong	3.676*** (0.643)	Christie's, London	3.492*** (0.566)	Bonhams, London	3.091*** (0.580)	Phillips, London	3.090*** (0.599)
Sotheby's, London	3.491*** (0.566)	Christie's, New York	3.284*** (0.565)	Bonhams, New York	2.639*** (0.573)	Phillips, New York	2.916*** (0.576)
Sotheby's, New York	3.176*** (0.565)	Auctionata, New York	3.991*** (0.944)	Kornfeld, Bern	3.702*** (0.574)	Aguttes, Paris Drouot	4.297*** (0.713)
Porro & C., Milan	3.817*** (0.775)	Thomaston Place, Thomaston	3.702*** (0.809)				

Panel D: Color, Size, Medium Controls in Model 4							
Nbr_Hue	0.052***	Sat_Std	-0.237*	Height	0.013***	Width^2	-0.001***
	(0.015)		(0.138)		(0.001)		(0.000)
Sat_Avg	0.573***	Lum_Std	-0.081	Width	0.008***	Oil	0.770***
	(0.113)		(0.113)		(0.001)		(0.121)
Lum_Avg	0.564***	Pct_Black	0.492***	Height^2	-0.001***	Watercolor	0.488***
	(0.149)		(0.116)		(0.000)		(0.126)

Panel E: Authenticity, Attribution, Provenance, Deceased Controls in Model 4							
Authenticity	0.061**	Literature	0.407***	Provenance	0.040	Deceased	0.055
	(0.031)		(0.086)		(0.045)		(0.043)
Attribution	-2.638***	Exhibition	0.124***				
	(0.305)		(0.033)				

Table III Painting Valuation and Dual-Color Hue Percentage

Pct_Dual_Color is the sum of dual-color hue percentages corresponding to the column header. The model specification follows Model 4 of Table II. Panel A reports the analysis of the subsamples where the number of hues (that exceed a 3% threshold) is equal to two. Panel B reports the estimates for the subsample where the number of hues (that exceed the 3% coverage threshold) is greater than one. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors (S.E.) are reported in parentheses and clustered at the auction branch level.

Panel A: # of Hues = 2

Dependent Variable: Ln(Price)	Red-Blue	Green-Blue	Red-Yellow	Yellow-Blue	Yellow-Green	Red-Green
Pct_Dual_Color	0.208**	0.333***	0.032	0.190**	0.069	0.075
	(0.086)	(0.065)	(0.061)	(0.077)	(0.070)	(0.089)
Color Controls	YES	YES	YES	YES	YES	YES
Size Controls	YES	YES	YES	YES	YES	YES
Medium Controls	YES	YES	YES	YES	YES	YES
Authenticity Controls	YES	YES	YES	YES	YES	YES
Provenance Controls	YES	YES	YES	YES	YES	YES
Deceased Dummy	YES	YES	YES	YES	YES	YES
Artist FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES
Auction Branch FE	YES	YES	YES	YES	YES	YES
Observations	1,186	1,186	1,186	1,186	1,186	1,186
R-squared	0.888	0.888	0.887	0.888	0.887	0.887

Panel B: # of Hues >1

Dependent Variable: Ln(Price)	Red-Blue	Green-Blue	Red-Yellow	Yellow-Blue	Yellow-Green	Red-Green
Pct_Dual_Color	0.202***	0.297***	-0.051	0.215***	0.012	-0.028
	(0.049)	(0.053)	(0.047)	(0.045)	(0.044)	(0.056)
Color Controls	YES	YES	YES	YES	YES	YES
Size Controls	YES	YES	YES	YES	YES	YES
Medium Controls	YES	YES	YES	YES	YES	YES
Authenticity Controls	YES	YES	YES	YES	YES	YES
Provenance Controls	YES	YES	YES	YES	YES	YES
Deceased Dummy	YES	YES	YES	YES	YES	YES
Artist FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES
Auction Branch FE	YES	YES	YES	YES	YES	YES
Observations	4,507	4,507	4,507	4,507	4,507	4,507
R-squared	0.852	0.852	0.852	0.852	0.852	0.852

Table IV Painting Valuation, Hue Percentage, and Hue Dispersion

Pct_Red, Pct_Orange, Pct_Yellow, Pct_Green, Pct_Blue, and Pct_Purple are the percentages of the six major hues analyzed in the images of non-figurative abstract art works at the pixel level. Pct_White is omitted as the benchmark. Disp_Red, Disp_Orange, Disp_Yellow, Disp_Green, Disp_Blue, Disp_Purple are the dispersions of the six major hues proxied by the average Euclidean distance between each pixel of a corresponding hue to the center pixel of that hue, normalized by the painting diagonal pixel length. The model specifications follow Model 4 of Table II. Models 2 and 3 are subsample analyses with the number of hues equal to one and greater than one, respectively. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors (S.E.) are reported in parentheses and clustered at the auction branch level.

Dependent Variable: Ln(Price)	Model 1	Model 2 # of Chromatic Hues =1	Model 3 # of Chromatic Hues >1
Pct_Red	0.267***	0.673***	0.195*
	(0.092)	(0.177)	(0.100)
Pct_Orange	-0.084	0.419	-0.049
	(0.074)	(0.437)	(0.106)
Pct_Yellow	0.066	0.066	0.108
	(0.080)	(0.165)	(0.077)
Pct_Green	0.029	0.176	0.098
	(0.088)	(0.240)	(0.096)
Pct_Blue	0.468***	0.804***	0.425***
	(0.111)	(0.202)	(0.116)
Pct_Purple	-0.162	0.412	0.062
	(0.232)	(0.362)	(0.264)
Disp_Red	-0.304	-0.624**	-0.092
	(0.222)	(0.271)	(0.144)
Disp_Orange	0.094	0.396	0.095
	(0.167)	(0.295)	(0.188)
Disp_Yellow	0.345**	0.780***	0.325*
	(0.148)	(0.265)	(0.166)
Disp_Green	0.416***	0.566	0.473**
	(0.150)	(0.520)	(0.183)
Disp_Blue	0.239	-0.018	0.258
	(0.150)	(0.307)	(0.220)
Disp_Purple	-0.116	0.024	0.002
	(0.146)	(0.405)	(0.163)
Color Controls	YES	YES	YES
Size Controls	YES	YES	YES
Medium Controls	YES	YES	YES
Authenticity Controls	YES	YES	YES
Provenance Controls	YES	YES	YES
Deceased Dummy	YES	YES	YES
Artist FE	YES	YES	YES
Year FE	YES	YES	YES
Month FE	YES	YES	YES
Auction Branch FE	YES	YES	YES
Observations	5,482	821	4,507
R-squared	0.855	0.903	0.854

Table V Painting Valuation and Hue Percentage in Golden Ratio Area

This table reports regressions of the log hammer price of the paintings on the hue percentages in four golden ratio areas covering a surface size of 4% each. Pct_Red, Pct_Orange, Pct_Yellow, Pct_Green, Pct_Blue, and Pct_Purple are the percentages of the six major hues analyzed in the corresponding four golden ratio squares. Pct_White is omitted as the benchmark. The model specifications follow Model 4 in Table I. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors (S.E.) are reported in parentheses and clustered at the auction branch level.

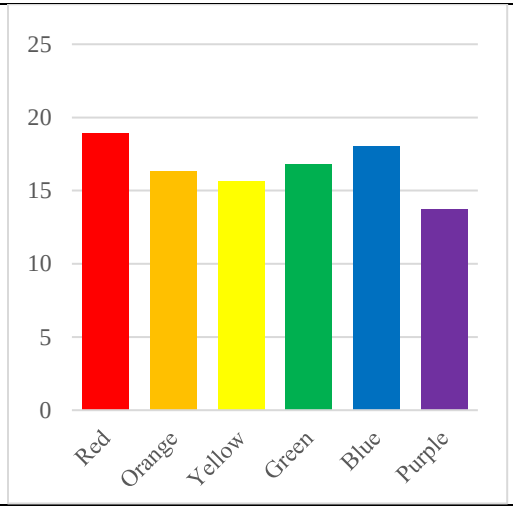
Dependent Variable:	Model 1	Model 2	Model 3	Model 4
Ln(Price)	Left-Top	Right-Top	Left-Bottom	Right-Bottom
Pct_Red	0.100	0.076	-0.001	-0.029
	(0.089)	(0.060)	(0.062)	(0.048)
Pct_Orange	-0.069	0.026	-0.177***	-0.113*
	(0.054)	(0.061)	(0.053)	(0.067)
Pct_Yellow	0.018	0.096	-0.009	0.014
	(0.064)	(0.068)	(0.053)	(0.056)
Pct_Green	0.075	0.037	-0.089	-0.004
	(0.087)	(0.091)	(0.069)	(0.080)
Pct_Blue	0.227**	0.324***	0.187***	0.238***
	(0.093)	(0.067)	(0.067)	(0.080)
Pct_Purple	0.074	-0.363**	-0.064	-0.491***
	(0.188)	(0.147)	(0.170)	(0.164)
Controls	YES	YES	YES	YES
Observations	5482	5482	5482	5482
R-squared	0.847	0.852	0.848	0.851

Table VI Bidding Results for Single-Color Abstract Art

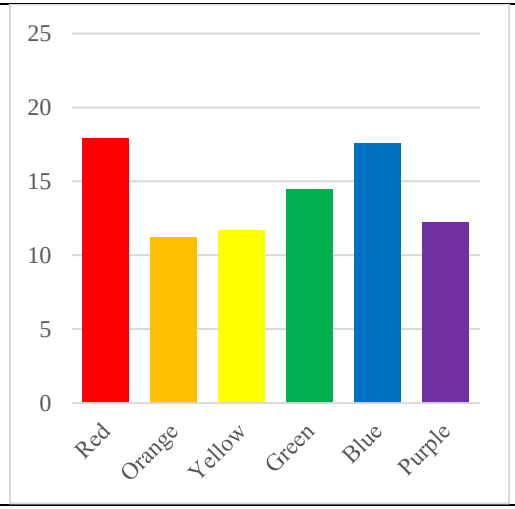
This table illustrates the average of the bids elicited via the BDM method (Becker, DeGroot, and Marschak (1964)) for single-color abstract art in the six hues (red, orange, yellow, green, blue, and purple). Each participant can bid any integer number from 0 to 100 ECU (experimental currency units) on each painting with a specific hue.

Panel A: Average of Biddings on Single-color Abstract Art of Six Major Hues in Three Countries

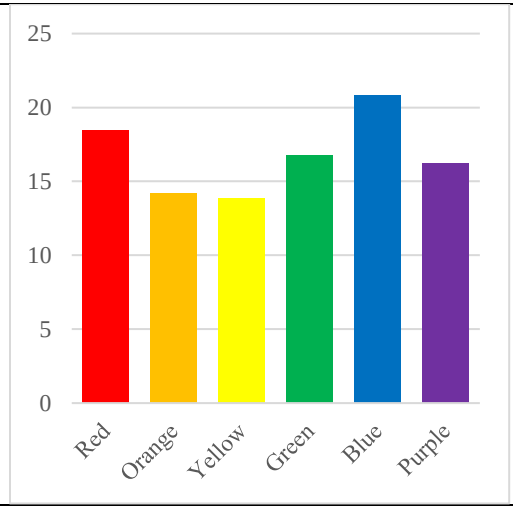
Shanghai, China (N=161)



Tilburg, the Netherlands (N=175)



Tucson, U.S.A. (N=129)



Panel B: Descriptive Statistics of Bids on Single Color Abstract Art by Six Major Hues in Three Countries

Shanghai, China (N=161)								**Tilburg, the Netherlands (N=175)**								**Tucson, U.S.A. (N=129)**							
Hue	Avg	STD	Min	25%	Med	75%	Max	Hue	Avg	STD	Min	25%	Med	75%	Max	Hue	Avg	STD	Min	25%	Med	75%	Max
Red	18.95	22.08	0	1	10	30	100	Red	17.92	23.57	0	0	7	30	100	Blue	20.84	25.19	0	0	10	30	90
Blue	18.02	22.14	0	1	8	30	95	Blue	17.57	23.30	0	0	8	30	100	Red	18.47	23.41	0	0	10	30	100
Green	16.78	21.76	0	0	7	25	100	Green	14.46	21.90	0	0	5	20	100	Green	16.78	23.15	0	0	5	25	90
Orange	16.35	21.09	0	0	6	25	100	Purple	12.23	21.80	0	0	1	12	100	Purple	16.19	22.10	0	0	6	25	95
Yellow	15.63	19.76	0	0	10	25	100	Yellow	11.66	18.25	0	0	3	20	100	Orange	14.21	20.53	0	0	4	20	90
Purple	13.70	19.98	0	0	5	15	100	Orange	11.23	18.63	0	0	1	15	100	Yellow	13.88	21.08	0	0	5	20	90

Table VII Hue and Valuation with Subject Fixed Effects

Red, Orange, Green, Blue, and Purple are fixed effects corresponding to the hues of the paintings that the participants bid on. Yellow is the omitted baseline category. PI stands for the Purchase Intention, calculated as the equally weighted average of four purchase intention ratings (on a scale from 1 to 7). The higher the rating, the higher the reported purchase intention. Rank is a rating from 1 to 6 of the single-color abstract paintings of the six hues (1 stands for the most favored painting and 6 for the least favored). We allow for tied rankings of multiple paintings. For example, one can rank both the red and blue painting to be No.1 (the most favored). In the regression analysis, Rank is reversed, in that a higher rating represents a higher place in the hierarchy. Order of Appearance in Model 4 is the display number of the painting: the six paintings within each round were displayed in a randomized sequence at the level of the participant. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors are reported in parentheses and clustered at the subject level.

	Model 1 Depend Variable: Bid			Model 2 Depend Variable: PI			Model 3 Depend Variable: Rank			Model 4 Depend Variable: Bid		
	CHN	NLD	USA	CHN	NLD	USA	CHN	NLD	USA	CHN	NLD	USA
Red	3.323**	6.263***	4.589***	0.0699	0.306***	0.200*	0.348*	1.189***	1.295***	3.343**	6.300***	4.568***
	(1.435)	(1.306)	(1.483)	(0.124)	(0.0927)	(0.110)	(0.191)	(0.166)	(0.188)	(1.438)	(1.304)	(1.490)
Orange	0.720	-0.423	0.333	-0.284**	-0.180**	-0.178**	-0.0683	-0.154	0.155	0.708	-0.407	0.317
	(1.172)	(1.050)	(1.366)	(0.116)	(0.0881)	(0.0893)	(0.174)	(0.163)	(0.181)	(1.166)	(1.048)	(1.368)
Green	1.149	2.800**	2.907**	0.144	0.0771	0.138	0.143	0.286	0.659***	1.155	2.837**	2.888**
	(1.317)	(1.188)	(1.409)	(0.118)	(0.0817)	(0.0960)	(0.191)	(0.173)	(0.187)	(1.313)	(1.198)	(1.413)
Blue	2.398*	5.914***	6.969***	0.179	0.399***	0.359***	0.304	1.160***	1.729***	2.384*	5.970***	6.881***
	(1.345)	(1.287)	(1.795)	(0.121)	(0.0912)	(0.109)	(0.204)	(0.191)	(0.211)	(1.347)	(1.292)	(1.802)
Purple	-1.932	0.577	2.318	-0.205	-0.0143	0.178	-0.578***	-0.194	0.736***	-1.926	0.626	2.305
	(1.513)	(1.474)	(1.760)	(0.131)	(0.0915)	(0.118)	(0.210)	(0.200)	(0.244)	(1.512)	(1.454)	(1.753)
Order of Appearance										0.117	-0.122	0.270
										(0.238)	(0.247)	(0.222)
Constant	15.63***	11.66***	13.88***	2.696***	2.010***	1.959***	3.509***	3.943***	4.357***	14.98***	12.29***	12.42***
	(0.851)	(0.765)	(0.966)	(0.0755)	(0.0534)	(0.0655)	(0.121)	(0.111)	(0.126)	(1.516)	(1.550)	(1.383)
Observations	966	1,050	774	966	1,050	774	966	1,050	774	966	1,050	774
R-squared	0.021	0.054	0.039	0.027	0.056	0.044	0.034	0.118	0.133	0.022	0.054	0.040
Number of Subjects	161	175	129	161	175	129	161	175	129	161	175	129
Subject FEs	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Table VIII Hue and Valuation with Control Variables

Red, Orange, Green, Blue, and Purple are hue fixed effects corresponding to the hue of the single-color paintings that the participants bid on. Yellow is the omitted benchmark. Gender equals 1 if the participant is female. Cognitive Score is the number of correct answers to the three questions of the Cognitive Reflection Test. Age is reported in the exit survey. Weather-induced mood is the rating of how one likes the weather on the day of the experiment (1 stands for "dislike very much" and 5 for "like very much"). Temperature, Humidity, Air Pressure, and Cloud Coverage are collected from the website Weather Underground (https://www.wunderground.com) at the time that a session started. Rain Before equals 1 if it rained shortly before the session and is recorded by the experimenter. Art Appreciation is the degree of affinity towards visual arts (1 stands for "dislike very much" and 5 for "like very much"). Art Background is the average of scaled responses to questions on the frequency of attending art-related events (0 is "almost never", 1 is "once or twice per week, 2 is "once or twice per month", and 3 is "once or twice per year"), and as to whether or not a participant has an art-related education (0 is "No", and 1 is "Yes"), has had painting classes (0 is "No", and 1 is "Yes"), or comes from a family with an art background (0 is "No", and 1 is "Yes"). Old Master equals 1 if the participant has a preference for the genre of Medieval, Renaissance and Baroque Art. Contemporary & Modern equals 1 if the participant prefers Impressionism, Modern Art, or Contemporary Art (the omitted benchmark is "No preference"). Expense is the sum of a participant's annual expenses on accommodation, transportation, food and drinks, tuition fee, and other expenses. Have A Loan equals 1 if the participant has a student loan. LH and HL are dummy variables indicating the Low-Saturation-High-Luminosity and High-Saturation-Low-Luminosity combinations, respectively (with the High-Saturation-High-Luminosity combination as benchmark). *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors (S.E.) are reported in parentheses and clustered at the subject level.

Dependent Variable: Bid	CHN		NLD		USA	
	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.
Red	3.323**	(1.448)	6.299***	(1.324)	4.544***	(1.543)
Orange	0.720	(1.182)	-0.253	(1.051)	0.400	(1.426)
Green	1.149	(1.329)	2.759**	(1.204)	2.752*	(1.453)
Blue	2.398*	(1.357)	6.092***	(1.292)	6.816***	(1.850)
Purple	-1.932	(1.527)	0.782	(1.480)	1.968	(1.799)
Gender	-5.142	(3.326)	1.269	(2.575)	5.327	(4.813)
Cognitive Score	-0.930	(1.817)	-4.942***	(1.192)	-1.732	(1.580)
Age	-0.292	(1.266)	0.790	(0.536)	0.449	(0.717)
Weather-Induced Mood	3.618**	(1.486)	2.861	(2.333)	3.324*	(1.937)
Temperature	1.988	(4.398)	-2.849	(2.120)	-0.509	(1.791)
Humidity	0.592	(1.098)	-0.289	(0.242)	-0.391	(0.619)
Air Pressure	-0.501	(0.853)	-0.290	(0.606)	0.328	(0.906)
Rain Before	-6.768*	(3.560)	-1.922	(5.301)	6.143	(6.691)
Cloud Coverage	-1.795	(2.722)	5.647	(3.744)	1.352	(3.498)
Art Appreciation	5.003**	(2.155)	0.149	(1.322)	-2.124	(2.728)
Art Background	-0.555	(13.27)	-2.888	(15.400)	-20.800	(16.07)
Old Master	4.448	(4.123)	2.886	(3.023)	-4.944	(5.475)
Modern & Contemporary	4.232	(2.651)	5.748*	(3.473)	0.650	(3.839)
Expense	-3.099	(2.094)	2.147	(4.782)	7.992**	(3.084)
Have A Loan	7.988	(6.019)	-0.537	(2.766)	-1.369	(3.642)
HL	-3.379	(5.845)	1.507	(3.233)	4.215	(5.082)
LH	-2.609	(4.509)	1.095	(3.736)	2.529	(5.327)
Constant	406.8	(815.5)	331.0	(665.5)	-313.1	(953.3)
Observations	966		1,044		750	
R-squared	0.133		0.164		0.105	
Subject FEs	No		No		No	

Table IX Hue and Emotions

Red, Orange, Green, Blue, and Purple are the hues of the single-color paintings that the participants bid on. Yellow is omitted as the benchmark. In Model 1, the dependent variable Pleasure is the average of pleasure measurements (1/2*P1+1/2*P2). In Model 2, the dependent variable Arousal is the average of arousal measurements (1/2*A1+1/2*A2) (see Online Appendix II). *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors are reported in parentheses and clustered at the participant level.

Dependent Variable	Model 1 Pleasure			Model 2 Arousal		
	CHN	NLD	USA	CHN	NLD	USA
Red	0.001	0.189	0.109	0.553***	0.609***	0.186
	(0.123)	(0.116)	(0.144)	(0.137)	(0.109)	(0.129)
Orange	-0.278**	-0.386***	-0.217*	-0.294**	-0.374***	-0.492***
	(0.113)	(0.112)	(0.126)	(0.114)	(0.104)	(0.125)
Green	0.201	0.326***	0.477***	0.208	0.351***	0.295**
	(0.130)	(0.118)	(0.146)	(0.126)	(0.0992)	(0.132)
Blue	0.128	0.466***	0.523***	-0.0901	-0.0286	-0.442***
	(0.123)	(0.109)	(0.147)	(0.122)	(0.120)	(0.144)
Purple	-0.171	0.0686	0.267*	0.432***	0.566***	0.345**
	(0.147)	(0.116)	(0.150)	(0.125)	(0.109)	(0.139)
Constant	3.998***	3.586***	3.667***	3.431***	3.146***	3.372***
	(0.0792)	(0.0720)	(0.0931)	(0.0783)	(0.0654)	(0.0840)
Observations	928	1,050	774	928	1,050	774
R-squared	0.024	0.069	0.060	0.076	0.114	0.101
Number of Subjects	161	175	129	161	175	129
Subject Fes	YES	YES	YES	YES	YES	YES

Table X Emotions and Single-color Abstract Art Valuations

Red, Orange, Green, Blue, and Purple are the hues corresponding to the single-color paintings that the participants bid on. Yellow is omitted as the benchmark. The dependent variable PI is the Purchase Intention, calculated as the equally weighted average of four purchase intention ratings (from 1 to 7). The higher the rating, the higher is the reported intention to buy a specific painting. The dependent variable Rank is the rating from 1 to 6 of the single-color abstract paintings. No.1 stands for the most favored painting and No.6 indicates the least favored. We allow for tied rankings for multiple paintings; for example, one can rank both the red and blue painting to be No.1 (the most favored). In the regression analysis, Rank is reversed such that a higher rating represents a higher place in the hierarchy. Pleasure is the average of the pleasure measurements (1/2*P1+1/2*P2) and Arousal is the average of the arousal measurements (1/2*A1+1/2*A2) (see Online Appendix II). *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors are reported in parentheses and clustered at the subject level.

Dependent variable:	Model 1 Bid			Model 2 PI			Model 3 Rank		
	CHN	NLD	USA	CHN	NLD	USA	CHN	NLD	USA
Pleasure	4.634***	6.235***	5.301***	0.650***	0.536***	0.477***	0.855***	0.943***	0.831***
	(0.557)	(0.607)	(0.622)	(0.0486)	(0.0393)	(0.0398)	(0.0507)	(0.0442)	(0.0501)
Arousal	-0.472	0.597	-0.378	0.0602	0.0625**	0.0804**	-0.0429	-0.0185	-0.0995*
	(0.497)	(0.462)	(0.518)	(0.0416)	(0.0307)	(0.0326)	(0.0510)	(0.0425)	(0.0536)
Constant	-0.357	-10.85***	-2.463	-0.144	-0.0798	-0.0343	0.266	0.0142	0.534**
	(2.036)	(2.845)	(2.785)	(0.188)	(0.169)	(0.188)	(0.211)	(0.229)	(0.253)
Observations	928	1,050	774	928	1,050	774	928	1,050	774
R-squared	0.172	0.309	0.208	0.490	0.460	0.430	0.285	0.330	0.276
Number of Subjects	161	175	129	161	175	129	161	175	129
Subject FEs	YES	YES	YES	YES	YES	YES	YES	YES	YES

Table XI Bidding Results on Dual-color Abstract Art

This table documents the summary statistics of the bidding results on dual-color abstract art. RB is the combination of Red-Blue, GB of Green-Blue, RY of Red-Yellow, YB of Yellow-Blue, YG of Yellow-Green, and RG of Red-Green. All dual-color paintings combine four primary hues (Red, Yellow, Green, and Blue) and the two constituent hues are configured in the same saturation-luminosity setting of one of the three possible combinations of High-High, High-Low, and Low-High. The two colors are positioned left and right in the dual-color abstract art and are equal in terms of the area size.

	Color Left	Color Right	Number of Observations	Mean	SD	Min	25%	Med	75%	Max
RB	Red	Blue	465	15.35	22.16	0	0	5	20	100
GB	Blue	Green	465	13.43	20.26	0	0	4	20	100
RY	Yellow	Red	465	13.25	20.16	0	0	5	20	100
YB	Blue	Yellow	465	12.91	20.44	0	0	3	17	100
YG	Green	Yellow	465	11.56	19.35	0	0	2	15	100
RG	Green	Red	465	11.10	19.06	0	0	1	11	100
Pooling			2,790	12.93	20.29	0	0	3	20	100

Table XII Dual-color Abstract Art and Constituent Colors

This table documents the relationship between bid, purchase intention, and rank (the dependent variables), and emotional states (pleasure and arousal) for the color combinations in the dual-color abstract art and its constituent colors. RB is the combination of Red-Blue, GB is Green-Blue, RY is Red-Yellow, YB is Yellow-Blue, YG is Yellow-Green, and RG is Red-Green. All dual-color paintings are made from the combinations of four primary hues (Red, Yellow, Green, and Blue) and the two constituent hues are configured in the same saturation-luminosity setting of one of the three possible combinations of High-High, High-Low, and Low-High. The two colors are positioned left and right in the dual-color abstract art and are equal in terms of the area size. Bid_Avg, PI_Avg, and Rank_Avg are the average of – respectively – bids on, purchase intentions of, and rankings of single-color paintings of the constituent colors. For example, Bid_Avg for the Red-Blue dual-color abstract art is the average of the bids on the red and blue single-color abstract art. Pleasure_Avg and Arousal_Avg are the averages of the respective Pleasure and Arousal states induced by viewing single-color paintings of the constituent colors. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The control variables in Panel B are the same as in the regressions of Table VII (gender, Cognitive Reflection Test score, age, weather-induced mood, weather conditions, art appreciation, art background, old master, modern & contemporary, expense, having a loan, HL, and LH). Standard errors are reported in parentheses and clustered at the participant level.

Panel A: Correlation between Valuation and Emotional Influences of Dual-color Abstract Art and Its Constituent Colors

	Bid		PI		RANK		Pleasure		Arousal
Bid_Avg	0.786***	PI_Avg	0.640***	RANK_Avg	0.368***	Pleasure_Avg	0.487***	Arousal_Avg	0.505***

Panel B: Relationship of Bidding Results on Dual-color Abstract Art and Its Constituent Colors

Dependent Variable: Bid	RB	YB	RY	GB	YG	RG
Bid_Avg	0.852***	0.820***	0.791***	0.784***	0.779***	0.690***
	(0.028)	(0.031)	(0.032)	(0.026)	(0.030)	(0.030)
Observations	460	460	460	460	460	460
R-squared	0.696	0.639	0.606	0.698	0.636	0.578
Constant	YES	YES	YES	YES	YES	YES
Control Variables	YES	YES	YES	YES	YES	YES

Table XIII Valuations and Emotional Influences of Dual-color Abstract Art

This table documents the relationship between the dependent variables bid, purchase intention, rank and the emotional states of pleasure and arousal for the color combinations in the dual-color abstract art and its constituent colors. RB is the combination of Red-Blue, GB is Green-Blue, RY is Red-Yellow, YB is Yellow-Blue, YG is Yellow-Green, and RG is Red-Green which is omitted as the benchmark. All dual-color paintings are made from the combinations of four primary hues (red, yellow, green, and blue) and the two constituent hues are configured in the same saturation-luminosity setting of one of the three possible combinations of High-High, High-Low, and Low-High. The two colors are positioned left and right in the dual-color abstract art and are equal in terms of the area size. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors are reported in parentheses and clustered at the participant level.

	Valuations			Emotional Influences	
Dependent variable:	Model 1 Bid	Model 2 PI	Model 3 Rank	Model 4 Pleasure	Model 5 Arousal
RB	4.258***	0.348***	1.019***	0.377***	-0.0688
	(0.718)	(0.0577)	(0.105)	(0.0667)	(0.0592)
GB	2.335***	0.233***	0.591***	0.341***	-0.268***
	(0.624)	(0.0529)	(0.101)	(0.0672)	(0.0678)
RY	2.153***	0.102*	0.458***	0.0871	-0.0538
	(0.662)	(0.0545)	(0.115)	(0.0704)	(0.0639)
YB	1.811**	0.0946*	0.303***	0.0656	-0.527***
	(0.710)	(0.0553)	(0.115)	(0.0739)	(0.0693)
YG	0.462	0.0616	0.0860	0.0323	-0.292***
	(0.687)	(0.0562)	(0.113)	(0.0706)	(0.0657)
Constant	11.10***	2.088***	2.910***	3.456***	3.746***
	(0.437)	(0.0341)	(0.0686)	(0.0435)	(0.0420)
Observations	2,790	2,752	2,790	2,790	2,790
R-squared	0.021	0.021	0.044	0.022	0.039
Number of Subjects	465	465	465	465	465
Subject FEs	YES	YES	YES	YES	YES

Table XIV Emotions and Dual-color Abstract Art Valuation

This table illustrates the emotional channel linking color to bid value, purchase intention, and rank of the dual-color abstract art. The dependent variable PI is the Purchase Intention calculated as the equally weighted average of four purchase intention ratings (from 1 to 7). The higher the rating, the higher the reported intention to buy a specific painting. The dependent variable Rank is the rating from 1 to 6 of the dual-color abstract art of the six combinations whereby No.1 stands for the most favored painting and No.6 indicates the least favored. We allow for tied rankings for multiple paintings. In the regression analysis, Rank is reversed such that a higher rating represents a higher place in the hierarchy. Pleasure is the average of the pleasure measurements (1/2*P1+1/2*P2) and Arousal is the average of the arousal measurements (1/2*A1+1/2*A2) (see Online Appendix II). RB is the combination of Red-Blue, GB is Green-Blue, RY is Red-Yellow, YB is Yellow-Blue, YG is Yellow-Green, and RG is Red-Green which is omitted as the benchmark. All dual-color paintings are made from combinations of two of the four primary hues (red, yellow, green, and blue) and the two constituent hues are configured in the same saturation-luminosity of either High-High, High-Low, or Low-High described earlier. The two colors are positioned on the left and right halves of the dual-color painting and are equal in terms of area size. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors are reported in parentheses and clustered at the participant level.

Dependent Variable:	Model 1 Bid	Model 2 PI	Model 3 Rank
Pleasure	4.055***	0.538***	0.858***
	(0.311)	(0.023)	(0.033)
Arousal	0.140	0.065***	-0.031
	(0.312)	(0.020)	(0.037)
Constant	-2.187	0.059	0.336**
	(1.485)	(0.100)	(0.143)
Observations	2,790	2,752	2,790
R-squared	0.188	0.503	0.284
Number of Subjects	465	465	465
Subject FEs	YES	YES	YES

Appendix I Variable Definitions

Panel A Variable Definitions for the Hedonic Pricing Model

Variable	Definition
Ln(Price)	Ln(Price) is the natural logarithm of hammer price in US Dollars.
Pct_Red	Pct_Red is the percentage of red pixels among all pixels in the image of the painting.
Pct_Orange	Pct_Orange is the percentage of orange pixels among all pixels in the image of the painting.
Pct_Yellow	Pct_Yellow is the percentage of yellow pixels among all pixels in the image of the painting.
Pct_Green	Pct_Green is the percentage of green pixels among all pixels in the image of the painting.
Pct_Blue	Pct_Blue is the percentage of blue pixels among all pixels in the image of the painting.
Pct_Purple	Pct_Purple is the percentage of purple pixels among all pixels in the image of the painting.
Pct_Black	Pct_Black is the percentage of black pixels among all pixels in the image of the painting.
Pct_White	Pct_White is the percentage of white pixels among all pixels in the image of the painting.
Sat_Avg	Sat_Avg is the average of pixel-level saturation on the colored part (excluding white and black hues) of the image of the painting.
Lum_Avg	Lum_Avg is the average of pixel-level luminosity on the colored part (excluding white and black hues) of the image of the painting.
Sat_Std	Sat_Std is the standard deviation of pixel-level saturation on the colored part (excluding white and black hues) of the image of the painting.
Lum_Std	Lum_Std is the standard deviation of pixel-level luminosity on the colored part (excluding white and black hues) of the image of the painting.
Nbr_Hue	Nbr_Hue is the number of chromatic hues exceeding 3% of painting surface.
Disp_Red	Disp_Red is the normalized dispersion of red hues based on pixel level. Dispersion is the average Euclidean distance of each red pixel to the center pixel of red hues in the painting image, normalized by the diagonal pixel length of the painting image.
Disp_Orange	Disp_Orange is the normalized dispersion of orange hues based on pixel level. Dispersion is the average Euclidean distance of each orange pixel to the center pixel of orange hues in the painting image, normalized by the diagonal pixel length of the painting image.
Disp_Yellow	Disp_Yellow is the normalized dispersion of yellow hues based on pixel level. Dispersion is the average Euclidean distance of each yellow pixel to the center pixel of yellow hues in the painting image, normalized by the diagonal pixel length of the painting image.
Disp_Green	Disp_Green is the normalized dispersion of green hues based on pixel level. Dispersion is the average Euclidean distance of each green pixel to the center pixel of green hues in the painting image, normalized by the diagonal pixel length of the painting image.
Disp_Blue	Disp_Blue is the normalized dispersion of blue hues based on pixel level. Dispersion is the average Euclidean distance of each blue pixel to the center pixel of blue hues in the painting image, normalized by the diagonal pixel length of the painting image.
Disp_Purple	Disp_Purple is the normalized dispersion of purple hues based on pixel level. Dispersion is the average Euclidean distance of each purple pixel to the center pixel of purple hues in the painting image, normalized by the diagonal pixel length of the painting image.
Disp_Black	Disp_Black is the normalized dispersion of black hues based on pixel level. Dispersion is the average Euclidean distance of each black pixel to the center pixel of black hues in the painting image, normalized by the diagonal pixel length of the painting image.
Disp_White	Disp_White is the normalized dispersion of white hues based on pixel level. Dispersion is the average Euclidean distance of each white pixel to the center pixel of white hues in the painting image, normalized by the diagonal pixel length of the painting image.
Height	The height of a painting measured in centimeters.
Width	The width of a painting measured in centimeters.
Oil	Oil refers to the Oil/Acryl Painting category based on the medium of a painting.

Watercolor	Watercolor refers to the Watercolor (or gouache) category based on the medium of a painting.
Drawing	Drawing refers to the Colored Drawing category based on the medium of a painting.
Authenticity	Authenticity is a dummy variable equaling one if the auctioned object contains any physically identifiable markings such as signature, date, or inscription, which help to confirm the authenticity of the art piece. Signature includes various types of signature including full names, monograms, initials, countersignatures, and stamps.
Attributed	Attributed is a dummy variable equaling one if the auctioned object had been recognized and disclosed by the auction house at any of the following levels: 1) attributed to the artist, 2) from the studio of the artist, 3) from the circle of the artist, 4) from the school of the artist, 5) after the artist, or 6) in the style or manner of the artist.
Literature	Literature is a dummy variable equaling one if there is textual information in the catalogue about literature covering the auctioned lot.
Exhibited	Exhibited is a dummy variable equaling one if there is textual information in the catalogue about the exhibition history of the auctioned lot.
Provenance	Provenance is a dummy variable equaling one if there is textual information in the catalogue about the provenance information (past ownership, previous sales information, etc.) of the auctioned lot.
Deceased	Deceased is a dummy variable equaling one if the artist is dead before the sale of the auctioned lot.
Soth_London	Soth_London is a dummy variable that equals one if the sale takes place at Sotheby's London.
Soth_NYC	Soth_NYC is a dummy variable that equals one if the sale takes place at Sotheby's New York.
Soth_Other	Soth_Other is a dummy variable that equals one if the sale takes place at one of Sotheby's other branches.
Chr_London	Chr_London is a dummy variable that equals one if the sale takes place at Christie's London.
Chr_NYC	Chr_NYC is a dummy variable that equals one if the sale takes place at Christie's New York.
Chr_Other	Chr_Other is a dummy variable that equals one if the sale takes place at one of Christie's other branches.
Bon_London	Bon_London is a dummy variable that equals one if the sale takes place at Bonhams London.
Bon_NYC	Bon_NYC is a dummy variable that equals one if the sale takes place at Bonhams New York.
Bon_Other	Bon_Other is a dummy variable that equals one if the sale takes place at one of Bonhams other branches.
Phi_London	Phi_London is a dummy variable that equals one if the sale takes place at Phillips London.
Phi_NYC	Phi_NYC is a dummy variable that equals one if the sale takes place at Phillips New York.
Phi_Other	Phi_Other is a dummy variable that equals one if the sale takes place at one of Phillips other branches.

Panel B Variable Definitions for Laboratory Experiment

Variable	Definition
Bid	Bid is the willingness to pay, elicited by means of the BDM method (Becker, DeGroot, and Marschak (1964)) for a painting. It ranges from 0 to 100 ECU (Experimental Currency Unit). Bidding 0 ECU indicates unwillingness to participate in the auction.
Purchase Intention (PI)	The Purchase Intention (PI) is the equally weighted average of the responses to four questionnaire items measuring the intention to purchase a painting (constructed following Dodds, Monroe, and Grewal (1991)). The four items are "I would love to buy this painting." (PI1), "I may spend more than intended on buying this painting." (PI2), "I would like to buy this painting immediately." (PI3), and "I regard the purchase of this painting as a waste of money." (PI4, reversed scale). Each item ranges from 1 to 7, where a higher value of the measurement indicates a stronger intention to purchase.
Rank	Rank is the ranking preference for the six paintings in each round. No.1 stands for the most favored painting and No.6 indicates the least favored. We allow for tied rankings for multiple paintings. For example, one can rank both the red and blue painting to be No.1 (the most favored). In the regression analysis, Rank is reversed such that a higher rating represents a higher position in the hierarchy.
Pleasure	Pleasure is the Pleasure-Displeasure dimension in the PAD emotional state model (Mehrabian and Russell (1974)). It responds to judgments of evaluation, with higher evaluations of stimuli being associated with greater pleasure induced by these stimuli (Mehrabian (1996)). Pleasure is the average

	of two items, "Unhappy-Happy" and "Annoyed-Pleased", each ranging from 1 to 7. A higher rating indicates more Pleasure.
Arousal	Arousal is the Arousal-Nonarousal dimension in the PAD emotional state model (Mehrabian and Russell (1974)). It responds to judgments of high-low stimulus activity in terms of level of mental alertness and physical activity (Mehrabian (1996)). Arousal is the average of two items: "Relaxed-Stimulated" and "Calm-Excited", each ranging from 1 to 7. A higher rating indicates greater Arousal.
Red	Red is the hue defined in the Munsell system with the parameter 0/360 in the HSV method.
Orange	Orange is the hue defined in the Munsell system with the parameter of 30/360 in the HSV method.
Yellow	Yellow is the hue defined in the Munsell system with the parameter of 60/360 in the HSV method.
Green	Green is the hue defined in the Munsell system with the parameter of 120/360 in the HSV method.
Blue	Blue is the hue defined in the Munsell system with the parameter of 240/360 in the HSV method.
Purple	Purple is the hue defined in the Munsell system with the parameter of 300/360 in the HSV method.
Hue Preference	Hue Preference is the individual rating of six hues (as reported in the exit survey). A rating of 1 means strongly dislike, 2 means dislike, 3 means neutral, 4 means like, and 5 means strongly like.
High-Saturation-High-Luminosity (HH)	In the Munsell system, color is decomposed into hue, chroma (saturation), and value (luminosity). Hue is the pure color. Higher saturation indicates that less neutral grey is added to the pure color, and a higher luminosity indicates that more pure white is added to the pure color. We define a representative example of the *High-Saturation-High-Luminosity (HH)* combination at 7 out of 10 in saturation and 8 out of 10 in luminosity according to the HSV method.
High-Saturation-Low-Luminosity (HL)	In the Munsell system, color is decomposed into hue, chroma (saturation), and value (luminosity). Hue is the pure color. Higher saturation means that less neutral grey is added to the pure color, and lower luminosity means that more pure black is added to the pure color. We define a representative example of the *High-Saturation-Low-Luminosity (HL)* combination at 7 out of 10 in saturation and 5 out of 10 in luminosity according to the HSV method.
Low-Saturation-High-Luminosity (LH)	In the Munsell system, color is decomposed into hue, chroma (saturation), and value (luminosity). Hue is the pure color. Lower saturation indicates that more neutral grey is added to the pure color, and higher luminosity indicates that more pure white is added to the pure color. We define a representative example of the *Low-Saturation-High-Luminosity (LH)* combination at 3 out of 10 in saturation and 8 out of 10 in luminosity according to the HSV method.
Order of Appearance	We assign a number from 1 to 6 to the red, orange, yellow, green, blue, and purple hues of the single-color paintings, respectively. The sequence of this number for each individual represents the order of appearance in which the paintings were displayed. For example, 2-1-6-4-3-5 means that the sequence of display is orange, red, purple, green, yellow, and blue. The order of appearance of the paintings is randomized at the participant level.
Gender	Gender equals 1 if the participant is female.
Cognitive Score	Cognitive Score is the number of correct answers to the three questions comprising the Cognitive Reflection Test (Frederick (2005)).
Age	Age is the participant's age as reported in the exit questionnaire.
Weather-Induced Mood	Weather-induced mood captures the degree to which a participant liked the weather on the day of the experiment; 1 is "dislike very much", 2 is "dislike", 3 is "neutral", 4 is "like", and 5 is "like very much".
Temperature	Temperature is gathered from Weather Underground (https://www.wunderground.com) in the hour when a session started and measured in Celsius (°C). The weather station chosen was the nearest to the corresponding experiment location and always within a distance of 15km.
Humidity	Humidity is gathered from Weather Underground (https://www.wunderground.com) in the hour when a session started and measured as a percentage from 0% to 100%. The weather station chosen was the nearest to the corresponding experiment location and always within a distance of 15km.
Air Pressure	Air Pressure is the atmospheric pressure gathered from Weather Underground (https://www.wunderground.com) in the hour when a session started and measured in Pascal (Pa). The

	weather station chosen was the nearest to the corresponding experiment location and always within a distance of 15km.
Cloud Coverage	Cloud Coverage is the degree of cloud coverage gathered from Weather Underground (https://www.wunderground.com) on the hour when a session started. 1 is "clear sky", 2 is "scattered clouds", 3 is "partly cloudy", 4 is "mostly cloudy", and 5 is "overcast or misty." The weather station chosen was the nearest to the corresponding experiment location and always within a distance of 15km.
Rain Before	Rain Before equals 1 if it had rained shortly before a session. This was recorded by the experimenter.
Art Appreciation	Art Appreciation is the degree of affinity towards visual arts. 1 indicates "dislike very much", 2 "dislike", 3 "neutral", 4 "like", and 5 "like very much".
Art Background	Art Background is an aggregate index composed of the answers to four questions about the frequency of attending art-related events (0 is "almost never", 1 is "once or twice per week, 2 is "once or twice per month", and 3 is "once or twice per year"), whether a participant has an art-related education (0 is "No", and 1 is "Yes"), whether he/she has had painting classes (0 is "No", and 1 is "Yes"), and whether he/she comes from a family with an artistic background (0 is "No", and 1 is "Yes").
Old Master	Old Master is a dummy variable gauging a subject's art taste. Old Master equals to 1 if the participant favors the genre of old masters. The participants can also indicate "No preference".
Modern & Contemporary	Contemporary & Modern is a dummy variable gauging a subject's art taste. Contemporary & Modern equals 1 if the participant prefers impressionism, modern art, or contemporary art. The participants can also indicate "No preference".
Expense	Expense is the annualized sum of the expenses related to accommodation, transportation, food and drinks, tuition fee, and other living expenses. It serves as a measure of participant's wealth level.
Have A Loan	Have A Loan equals 1 if the participant had a student loan at the time of experiment and 0 otherwise.

Online Appendix

Online Appendix I Color Theories and Decision Making

1. Color Theories

Theories of colors have been proposed and developed through the ages, starting with Empedocles and Aristotle, by painters, physicists, philosophers, psychologists, and recently neuroscientists. These theories have mainly focused on color systems, the emotional impacts of colors, and vision processing.

1.1 Color Systems

A color system consists of three major aspects: the composition of primary colors, color relationships, and their fundamental attributes. Primitive color systems can be traced back to the classical period, specifically to Empedocles in 5th century BC and to Aristotle who included an analysis of color in his *De Sensu et Sensibilibus* (On Sense and the Sensible) and *De Coloribus* (On Color). Primitive color systems in the classical period and the Middle Ages used subjective definitions of primary colors, which were often linked to physical substances such as the elements (air, water, earth, fire), or to minerals and stones which were allotted medical qualities. The theory of color was taken up again in the Renaissance in treatises by e.g. Leon B. Alberti with *Della Pittura* (*On Painting*), and Leonardo da Vinci in *A Treatise on Painting* (Hoeppe (2007), Sorabji (1972)).

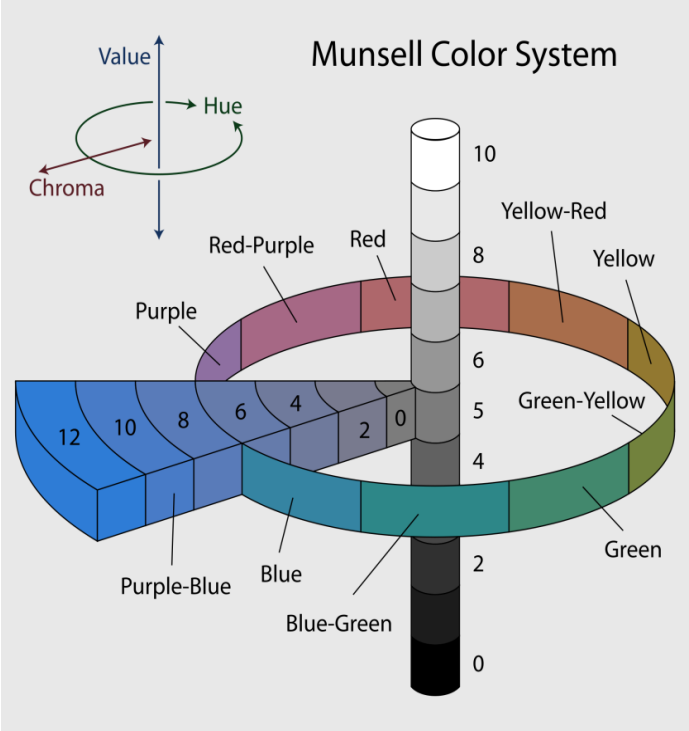
In 1666, Sir Isaac Newton decomposed natural light by means of two prisms and proposed a color system with seven primary colors. Johann Wolfgang von Goethe (1840) studied the psychological effects of colors. He also proposed a color wheel with the primary colors of red, yellow, and blue (RYB), and the secondary colors orange, violet, and green. In his framework, the semi-circle from green through yellow and orange to red are on the Plus Side, which stands for action, brightness, warmth, repulsion, etc. The other semi-circle, consisting of blue and violet is on the Minus Side and represents shadow, darkness, coldness, and distance. Around the same time, physicists Thomas Young (1802) and Hermann von Helmholtz (1852) advocated the three primary colors, red, green and blue, based on the different types of photoreceptors in the human eye (the Young-Helmholtz or

Trichromatic Theory). Helmholtz also introduced three dimensions of color that have remained in use: Hue, Saturation (also called Intensity or Chroma), and Brightness (also called Luminosity, Lightness, or Value).

James Clerk Maxwell (1857) laid the foundation of the quantitative measurement of color, colorimetry. He realized that the three colors from the RGB system were sufficient to produce the entire color space, and this insight led to the CIE color system (*Commission Internationale de l'Eclairage* / International Commission on Illumination). Physiologist Ewald Hering proposed in 1892 the Color Opponent theory, which stressed that yellow, then regarded as a mixture of red and green, was actually an elementary color in human experience. He therefore proposed to expand the group of primary colors to four (RYGB), which led to the Natural Color System (NCS) standard. Maxwell also conjectured that red was complementary to green, yellow to blue, and white to black.[1] In order to arrange colors on perceived equidistance, the American painter Albert Henry Munsell (1905, 1915) introduced a color-tree system. Hue, Chroma (Saturation), and Value (Luminosity) are the three fundamental coordinates in the Munsell system with red, yellow, green, blue and purple qualified as primary colors. The Munsell system is structured in the form of an asymmetric spindle (Figure 1, below). Along the vertical coordinate is the luminosity, representing the ratio of white to black added to a hue. On each horizontal disc, the hues red, yellow, green, blue and purple, and their five intermediate hues (such as yellow-green), appear in a circle. For a given hue of a certain luminosity, saturation is 0 in the innermost part of the spindle and the color increases in intensity as saturation increases (moving outwards). The Munsell color tree blossomed and was refined over time and is probably the most popular color system in use today. This framework also guides our choice of six major hue families (red, orange, yellow, green, blue, and purple), and further decomposes a color by means of two more dimensions (saturation, and luminosity).

[1] Hurvich and Jameson (1957) performed a hue cancellation experiment with quantitative data that supported the opponent-process theory.

Figure 1. Munsell Color System[2]



1.2 Color Processing and Perception

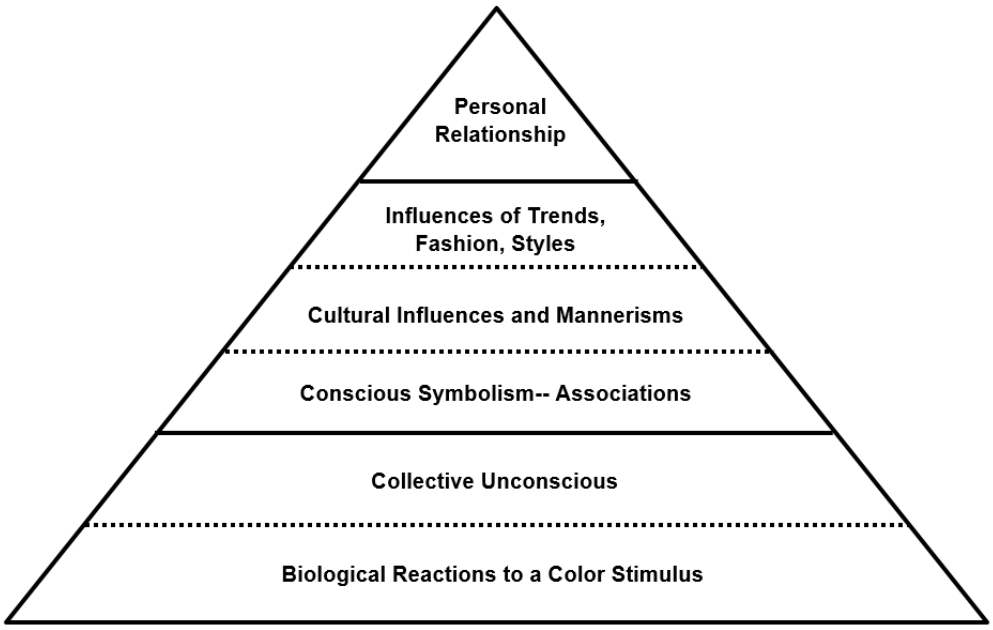
There are three types of cones in the human eye, which have peak sensitivity to long, medium, and short wavelength light, respectively termed as the L-cones, M-cones, and S-cones. The colors arousing the highest sensitivity in each are red, green, and blue (in this order). A combination of all three types of cones is needed to distinguish black and white. The L-cone and M-cone are both needed to differentiate red and green. Yellow is detected by the combination of L- and M-cones, and blue is recognized by the S-cone along with a weak but necessary stimulus to the L- and M-cones (Hunt (2004)).

Color perception is both an objective and subjective process: although color is nothing other than a form of energy, it can influence mental and emotion states. Mahnke (1996) argues that color perception induces visual, associative, synesthetic, symbolic, emotional, and physiological effects, based on how the color is experienced. He proposes a color experience pyramid with six levels of factors describing this experience (Figure 2, below).

[2] Released under the Creative Commons Attribution ShareAlike 3.0 license. Copyright: Jacob Rus.

The basic layer results from biological or physiological actions beyond our control, to color stimuli that have traces of our evolutionary heritage. An example consists of the production and release of hormones after a neural pathway carries color or light stimulation to the hypothalamus, and the pineal and pituitary glands. The second level is composed of associations not controlled for or caused by reason. The third level consists of a range of symbols related to color. At the fourth level are the color characteristics of specific cultures, while the fifth layer represents influential trends, styles, and fashions. The sixth level reveals personal preferences of color.

Figure 2. Color Experience Pyramid (by Frank H. Mahnke)



1.2.1 Single-color Effects

While the psychological effect of color is complex, some studies find commonalities in reactions to color across individuals (Evans (1974), Birren (1945, 1978), Hilbert (1987), Dove (1992), Crozier (1996), Feisner (2001)), which Cheng (2002) summarizes. Red is associated with being adventurous, aggressive, social, powerful, protective, brave, arousing, passionate, sexy, and exiting. Orange, as a mixture of red and yellow, is energetic, motivated, and jovial. Yellow is cheerful, affectionate, and impulsive. Green is associated with being stable, peaceful, calm, quiet, natural, and restful, and blue with dignity,

conservatism, poise, and reserve but also with being relaxed, comfortable, soothing, and intellectual. Purple or violet arouses, as a blend of red and blue, sensations of elegance, mysticism, and magic. White is usually regarded as an achromatic "color" and is connected to spirituality, hope, holiness, purity, cleanness, and innocence. The other achromatic "color", black, is related to power, protection, status, elegance, richness, and dignity. Grey refers to being conservative, quiet, tired, passive, and lifeless.

Valdez and Mehrabian (1994) quantitatively test the emotional effects of color by means of the Pleasure-Arousal-Dominance (PAD) emotion model. They find that blue, green, and purple induce pleasure, whereas yellow, green-yellow, and yellow-red decrease the pleasure level (with red being a neutral color in terms of pleasure). On the arousal scale, green-yellow, green, and blue-green lead to greater arousal levels, but purple-blue and yellow-red decrease arousal. There is little relation of color to the Dominance emotion. With regard to the other dimensions of color, namely luminosity and saturation, pleasure is positively associated with both luminosity and saturation, and both arousal and dominance are negatively related with luminosity but positively with saturation. Colors of high saturation tend to be perceived as warm while colors of high luminosity tend to be viewed as cool.

1.2.2 Color Combinations

An early study on color combinations is by Chevreul (1839), who documents that color interactions induce different visual effects than single colors. Washburn, Haight, and Regensburg (1921) report that whether or not a color combination is experienced as pleasant is strongly correlated with how the constituent colors are experienced, an insight confirmed by Guilford (1931, 1934), Lo (1936), Hogg (1969), and Ou *et al.* (2004a, 2004b).

2. Colors and Decision Making

The number of studies of the effects of color on decision making is growing in the fields of consumer behavior, risk attitude, and financial decisions. For instance, Bellizzi and Hite (1992) show that changing colors in a shopping environment affects purchase behavior through the emotional channel of affection/pleasure (rather than arousal). Similarly, Brengman (2002) studies how different color combinations, in terms of hue,

saturation, and luminosity, influence customers' emotional states in a department store setting, which then also affects purchasing behavior. In a financial setting, most studies focus on the avoidance effect induced by red stimuli. Kliger and Gilad (2012) prime subjects with a text on either a green or red background, and find that red background priming significantly increases the risk aversion in subjects' investment decisions. Chan and Park (2015) find that red in a business plan reduces the favorable decisions in venture investment. Gnambs, Appel, and Oeberst (2015) demonstrate that subjects make less risky decisions in an online test when shown a red university logo than subjects facing a grey logo. Bazley, Cronqvist, and Mormann (2017) show that portfolio losses and negative stock paths displayed in red lead to reductions in risk-taking and lower return expectations, respectively. There is also research on color effects regarding non-financial decisions. Garrett and Brooks (1987) find that ballot color influences voting results and is gender dependent. Genschow, Reutner, and Wänke (2012) document that the package color red serves as a stop sign and discourages food intake. Deng, Hui, and Hutchinson (2010) find that consumers ignore color lightness (luminosity) and focus on hue when customizing shoe colors online.

However, only very few papers touch on color attributes as pricing factors in an art auction context, or on pricing colors directly. Etro and Pagani (2012) document that the market for paintings and painted altarpieces is affected by the scarcity of pigment needed to make specific colors such as ultramarine blue, a supply-side rather that a demand-side effect, which was reflected in the sales prices of those art objects. Pownall and Graddy (2016) use RGB color decomposition to study 178 figurative prints of Andy Warhol's Monroe and Chairman Mao sold in 2012. Garay and Pérez (2018) apply a similar methodology to 1627 non-abstract paintings of 5 Latin-American painters. Both studies find that, without differentiating among the actual hues, higher intensity and lower lightness positively affect the art works' prices.[3] Charlin and Cifuentes (2018) study color attributes in 169 Mark Rotho's paintings and find that RGB color decomposition is inferior to HSV color decomposition in terms of precision and can miss important information.

[3] A problematic aspect of both studies is that averaging the RGB values of the whole art work's surface blurs the results (e.g. a painting that is one half blue and one half yellow, is considered as green). Furthermore, when analyzing figurative paintings, one cannot isolate any hue effects as hues "interact" with the painted objects (or subjects).

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Online Appendix II Emotion Measurement and Purchase Intention

This table shows the four-item short version of Pleasure-Arousal-(Dominance) emotion scale (PA(D)) and purchase intention scale (PI) that we used to measure the participants' self-reported emotions after they viewed a painting. We elicited evaluations of emotions and purchase intention by asking "How do you feel when looking at this painting?" and "To what extent do you agree or disagree?" and instructed the participants to click on one button per item. The middle point of each item was labeled "Neutral" above. The Pleasure emotion is calculated as the average of scores from P1 and P2, the Arousal emotion as the average of scores from A1 and A2, the Purchase Intention is calculated as the average of scores from PI1, PI2, PI3, and PI4 (reversed). The sequence of emotion scale from up to down was randomized and fixed as A2, P1, A1, and P2 across all rounds and all sessions. The scores assigned were not shown on the experiment interface.

Panel A: Emotion Measurement

How do you feel when looking at this painting?

Dimension	Item	Neutral							
Pleasure	P1	Unhappy	■	■	■	■	■	■	■	Happy
	P2	Annoyed	■	■	■	■	■	■	■	Pleased
Arousal	A1	Relaxed	■	■	■	■	■	■	■	Stimulated
	A2	Calm	■	■	■	■	■	■	■	Excited
Score Assigned			1	2	3	4	5	6	7	

Panel B: Purchase Intention (Continued)

To what extent do you agree or disagree?

Question	Item	Neutral							
I would like to buy this painting.	PI1	Disagree	■	■	■	■	■	■	■	Agree
I may spend more than intended on buying this painting.	PI2	Disagree	■	■	■	■	■	■	■	Agree
I would like to buy this painting immediately.	PI3	Disagree	■	■	■	■	■	■	■	Agree
I regard the purchase of this painting as a waste of money. (Reversed)	PI4	Disagree	■	■	■	■	■	■	■	Agree
Score Assigned			1	2	3	4	5	6	7	

Online Appendix III Overview of Experiment Sessions

This overview of the experimental sessions includes the locations, laboratories, number of sessions, number of subjects who showed up, number of non-color-blind subjects, endowment exchange rates, and payment methods. Subjects who failed the color vision impairment test are classified as color vision deficient.

Location	Laboratory Name	Number of Sessions	Number of Participants		Endowment Exchange Rate (100 ECU =)	Payment Method (subsequent to the lab experiment)
			Total	Without Color Vision Deficiency		
Shanghai, China	Finance Lab	14	166	161	25 CNY	Wechat Pay
Tilburg, the Netherlands	CentERlab	16	183	175	10 EUR	Bank Transfer
Tucson, U.S.A.	Economic Science Laboratory	15	132	129	16 USD	Cash

Online Appendix IV Experiment Instructions

Welcome to this experiment!

If you follow these instructions carefully, and make good decisions, you can make some money and also receive a high quality physical print in A3 size of a painting.

In the experiment, you will give your opinion about, and bid for high quality prints of different paintings. You will see images of these paintings on the screen during the session.

Our experiment consists of two parts. The first part is for practice and does not count. This part is to familiarize you with our procedures. The second part is similar to the first, except that it does count toward your final outcome.

You will see a number of prints.

- First, you give your opinion about these prints.
- Second, you also bid some money to buy the print.

How does this work? You will start the experiment with 100 ECU (Experiment Currency Units). The exchange rate is 10 ECU=1 Euro.

The print will be sold in the following way. You are required to bid an amount from 0 to 100 ECU on every print. If you do not want to bid for it, you can input 0. The sequence of events is as follows

1. You type in your bid for a print.
2. The selling price for each print is generated by the computer. The selling price will be taken from a range of typical prices of the print.
3.1 If your bid is equal to or higher than the selling price, you get the print and only pay the selling price for it.
3.2 If your bid is less than the selling price, you do not get the print and you pay 0.

Under this procedure, it is in your best interest to bid the amount that you think the print is worth to you. Let us call this amount your valuation. The two examples below illustrate what can happen if you bid less or more than your valuation.

Case 1, you bid too low:
Suppose your valuation for an item is 80 ECU and you bid only 40 ECU for it. The selling price turns out to be 50 ECU. Since your bid is less than the selling price, you do not buy the print.
On the other hand, suppose you had bid your valuation of 80 ECU. In that case, you would have received the print and paid only 50 ECU (the selling price). So you would have received a print with the value of 80 ECU to you while paying 50 ECU, and therefore a payoff of 30 ECU. That means you would have been 30 ECU better off than you were by bidding 40 ECU.

Case 2, you bid too high:

Suppose your valuation for an item is 20 ECU and you bid 80 ECU for it. The selling price turns out to be 30 ECU. Since your bid is higher than the selling price, you will get the print and pay the selling price of 30 ECU. So, you buy a print for 30 ECU but it is worth only 20 ECU to you. This means that you incur a loss of 10 ECU.
On the other hand, suppose you had bid your valuation of 20 ECU. In that case, you would have not received the print and not paid the 30 ECU. So, you would have avoided a loss of 10 ECU. That means you would have been 10 ECU better off by bidding 20 ECU.

In the bidding process, it is in your best interest to think about your valuation for the print, and then to make a bid equal to your valuation. You are on average worse off by bidding either higher or less than your own valuation.

- You don't need to think about the allocation of your funds (ECU) over different prints because for every print you can bid between 0 and 100 ECU.

- At the end of the experiment, **only one** of the prints for sale in Part 2 will be randomly selected and it is then revealed whether you have made a successful bid and receive the print.

    - If you had made a bid equal to or higher than the selling price, you will pay the selling price and will get the print. You will keep the rest of your 100 ECU which will be paid out to you.

    - If you had made a bid less than the selling price for that print, you do not get a print, and you keep your 100 ECU which will be paid out to you.

(The End)

Online Appendix V Exit Questionnaire

1. What's your gender?
   ☐ Female ☐ Male

2. In which year were you born?
   _____

3. What's your nationality (*Please include original and acquired if any.*)?
   _____/_____/_____

4. What level of education are you currently following? (*Please mark only one.*)
   ☐ Bachelor or Equivalent
   ☐ Pre-Master or Master
   ☐ Research Master, MPhil or Doctoral Degree

5. What is (was) the name of your study program?
   _____

6. How much do you like visual arts (painting, prints)?
   ☐ Very much
   ☐ A lot
   ☐ Neutral
   ☐ Dislike
   ☐ Highly Dislike

7. What's your most favorite art genre? (*Please mark only one.*)
   ☐ Old Masters
   ☐ Impressionist and Modern
   ☐ Contemporary
   ☐ No preference

8. How often do you participate in art-related events (*E.g. exhibitions, auctions, and galleries' openings*), read art magazines, and watch art documentaries?
   ☐ Once or twice per week
   ☐ Once or twice per month
   ☐ Once or twice per year
   ☐ Almost Never

9. Do you have an art-related education?
   ☐ Yes ☐ No
   Do you have a degree of BA/MA in fine arts or art history?

☐ Yes ☐ No

Do (Did) you have painting classes in an academy or private art tuition?

☐ Yes ☐ No

Do you come from a family with an art background?

☐ Yes ☐ No

10. How many paintings or prints are (were) there in your parents' house?
    - ☐ More than 10
    - ☐ 7 to 10
    - ☐ 4 to 6
    - ☐ 1 to 3
    - ☐ None

11. Have you ever realized or been informed that you are color blind?
    ☐ Yes ☐ No

12. What's your most favored color? (*Please mark only one.*)
    - ☐ Red
    - ☐ Yellow
    - ☐ Purple
    - ☐ White
    - ☐ Grey
    - ☐ Green
    - ☐ Blue
    - ☐ Orange
    - ☐ Black

13. What's your least favored color? (*Please mark only one.*)
    - ☐ Red
    - ☐ Yellow
    - ☐ Purple
    - ☐ White
    - ☐ Grey
    - ☐ Green
    - ☐ Blue
    - ☐ Orange
    - ☐ Black

14. How much do you like the color…? (*Please check the appropriate box for each row.*)

Color	Strongly Dislike	Dislike	Neutral	Like	Strongly Like
Red	☐	☐	☐	☐	☐
Green	☐	☐	☐	☐	☐
Yellow	☐	☐	☐	☐	☐
Blue	☐	☐	☐	☐	☐
Purple	☐	☐	☐	☐	☐
Orange	☐	☐	☐	☐	☐
White	☐	☐	☐	☐	☐
Black	☐	☐	☐	☐	☐

Grey	☐	☐	☐	☐	☐
Scores Assigned[28]	1	2	3	4	5

15. Do you have a part-time job?
    ☐ Yes ☐ No

16. Do you have a full-time job?
    ☐ Yes ☐ No

17. How much money do you receive per month from working, work study, your parents, and other sources?

    _____

18. What's your average monthly expenditure in the term of euro on the following aspects? (*Please Round up to 100 euro.*)

    Accommodation (including rent) or Mortgage _____

    Transportation (including bus, car payment and insurance, flight, etc.) _____

    Food and Drinks _____

    Tuition Fee (including the amount that parents or others pay and loans) _____

    Others _____

19. Do you currently have a student loan?
    ☐ Yes ☐ No

20. How do you like the weather today?
    ☐ I like it very much
    ☐ I like it
    ☐ Neutral
    ☐ I do not like it
    ☐ I dislike it very much

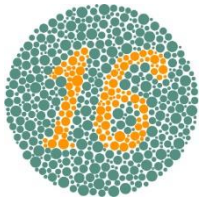
21. Did you recognize any painter of the art works shown earlier in this experiment?
    Please write down the serial number before the artist name.

    _____

[28] Scores assigned were not shown on experiment interface to subjects.

1. Paul Cezanne, 2. Pieter Breughel, 3. Damien Hirst, 4. Jeff Koons,
5. Marc Chagall, 6. Henri Matisse, 7.Joan Miro, 8. Claude Monet,
9. Mark Rothko, 10. Ton Schulten, 11. Pablo Picasso, 12. Peter-Paul Rubens,
13. Piet Mondriaan, 14. Alberto Giacometti, 15. Andy Warhol,
16. Rembrandt Harmenszoon van Rijn, 17. Vincent van Gogh,
18. Pierre-August Renoir, 19. Alfred Sisley, and 20. Winslow Homer.

22. Please fill in the number shown on each picture.



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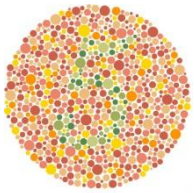

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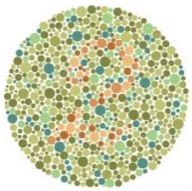

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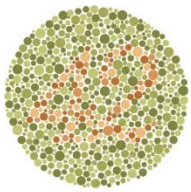


_____

23. Please calculate and answer the question below.

A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball.
How much does the ball cost? _____ cents

If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets? _____ minutes

In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake? _____ days

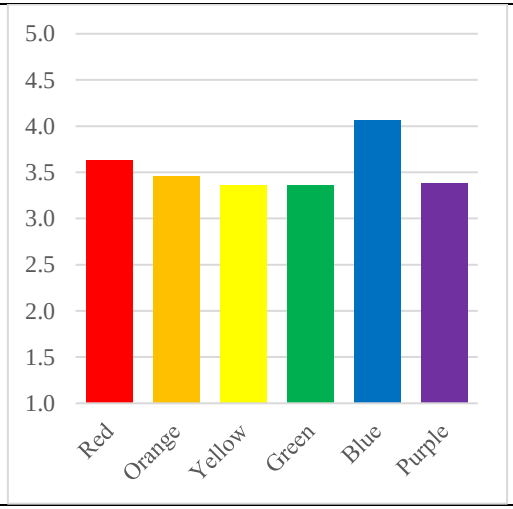
(The End)

Online Appendix VI Hue Rating by Country (from Exit Survey)

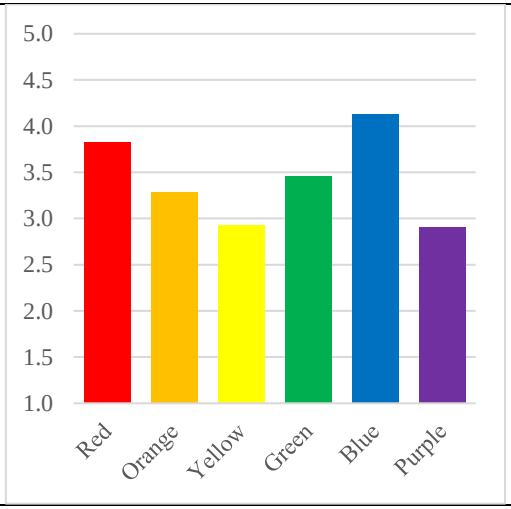
This table illustrates the average of the ratings given to the six major hues (red, orange, yellow, green, blue, and purple) by the participants in the exit survey. A rating of 1 signifies a strong dislike, 2 expresses a dislike, 3 is the neutral stance, 4 refers to a liking, and 5 represents a strong preference.

Panel A: Average Ratings of Six Major Hues in Three Countries

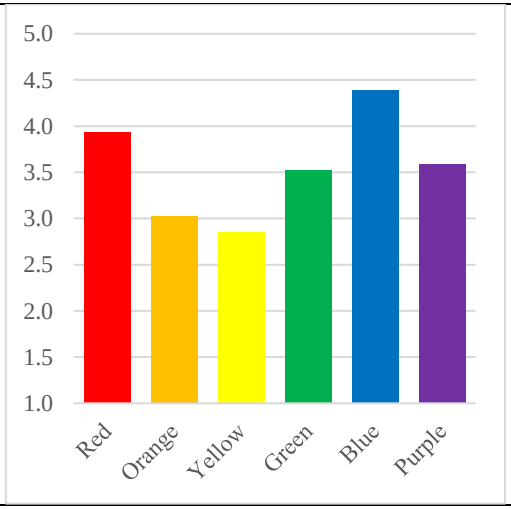
Shanghai, China (N=161)



Tilburg, the Netherlands (N=175)



Tucson, U.S.A. (N=129)



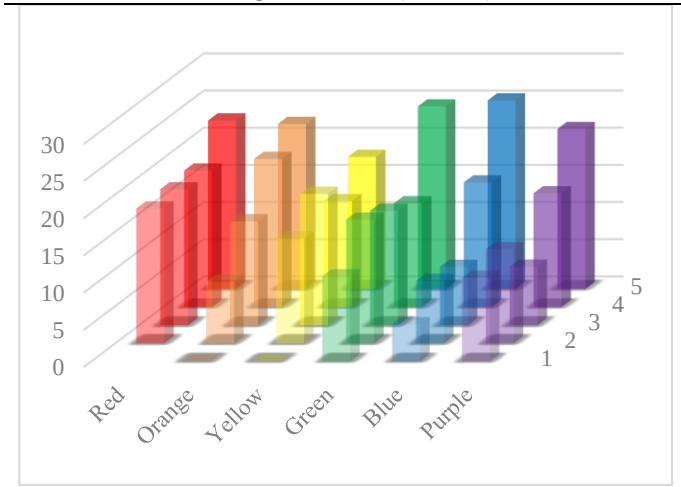
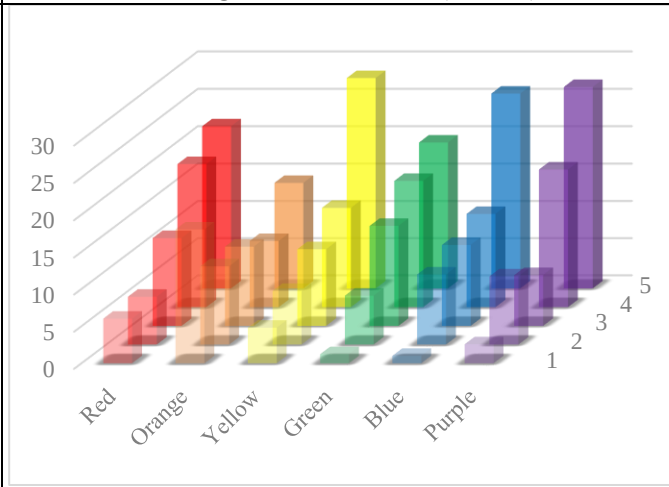
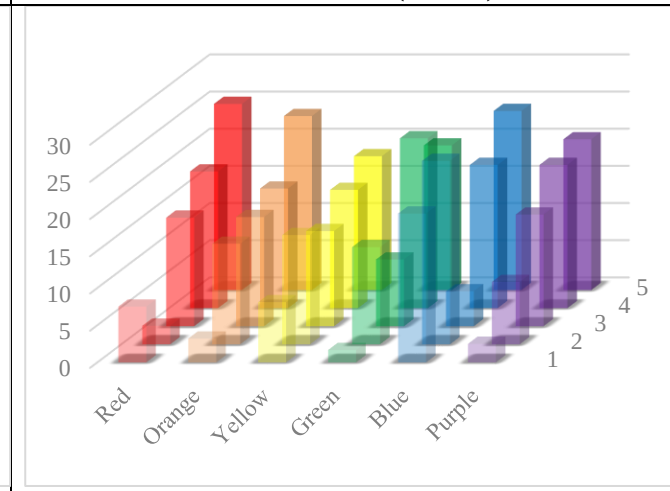
Panel B: Descriptive Statistics of Ratings by Six Major Hues in Three Countries

Shanghai, China (N=161)								Tilburg, the Netherlands (N=175)								Tucson, U.S.A. (N=129)							
Hue	Avg	STD	Min	25%	Med	75%	Max	Hue	Avg	STD	Min	25%	Med	75%	Max	Hue	Avg	STD	Min	25%	Med	75%	Max
Blue	4.07	0.95	1	4	4	5	5	Blue	4.13	0.85	1	4	4	5	5	Blue	4.39	0.79	1	4	5	5	5
Red	3.63	0.86	2	3	4	4	5	Red	3.82	0.82	1	3	4	4	5	Red	3.93	0.80	1	4	4	4	5
Orange	3.45	0.87	1	3	4	4	5	Green	3.46	1.24	1	3	4	4	5	Purple	3.59	1.16	1	3	4	5	5
Purple	3.39	1.13	1	3	3	4	5	Orange	3.30	1.09	1	2	4	4	5	Green	3.53	1.05	1	3	4	4	5
Green	3.36	1.12	1	3	3	4	5	Yellow	2.93	1.13	1	2	3	4	5	Orange	3.02	1.14	1	2	3	4	5
Yellow	3.36	0.88	1	3	3	4	5	Purple	2.90	1.23	1	2	3	4	5	Yellow	2.85	0.99	1	2	3	4	5

Online Appendix VII Bidding Results for Single-Color Abstract Art and Hue Preferences

This table illustrates the average bids for each of the five ratings for each hue as shown in two-way bar charts. The horizontal axis shows the six hues, while the depth axis (labeled from 1 to 5) indicates the rating of a given hue. The height of each bar represents the average valuation of the corresponding hue (from 1 to 5). For example, the height of the red bar located at the crossing of "Red" and "5" is the average bid on the red single-color abstract art piece among participants who rated red to be "5" (a strong liking).

Panel A: Average Bid for Single-color Abstract Art of Six Major Hues Grouped by Corresponding Affect Level

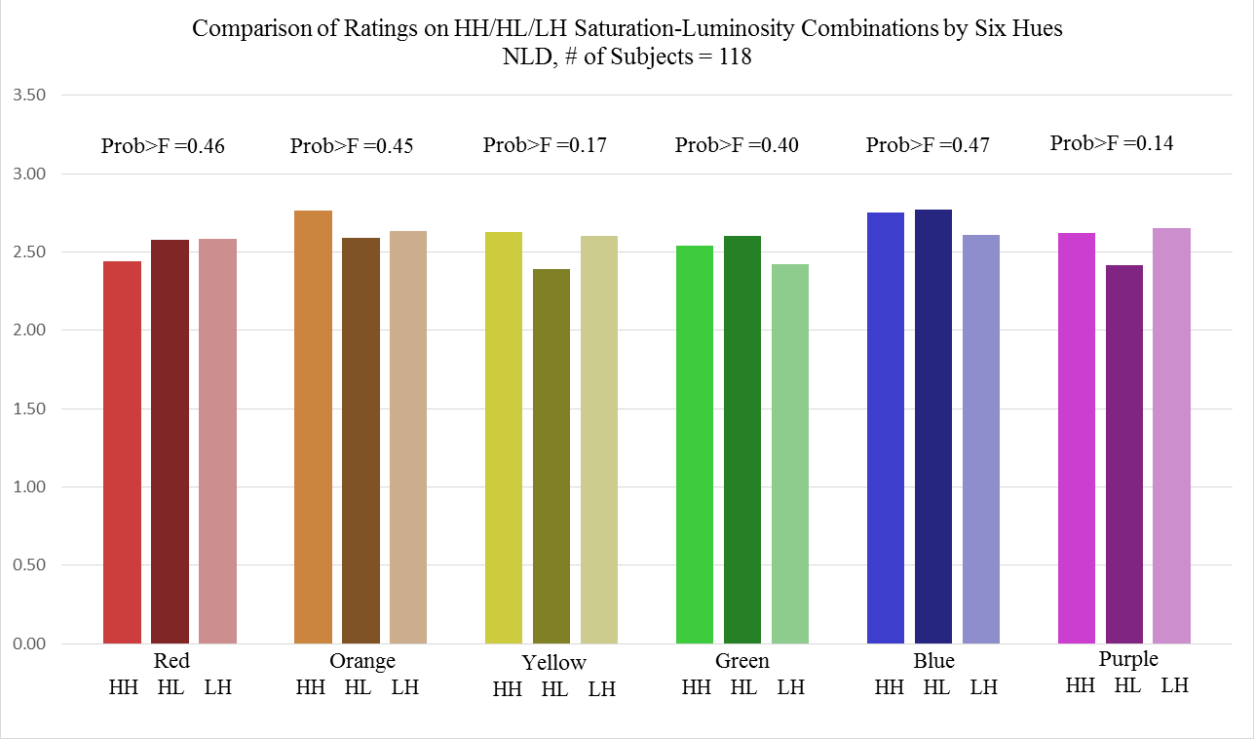
Shanghai, China (N=161)	Tilburg, the Netherlands (N=175)	Tucson, U.S.A. (N=129)
		

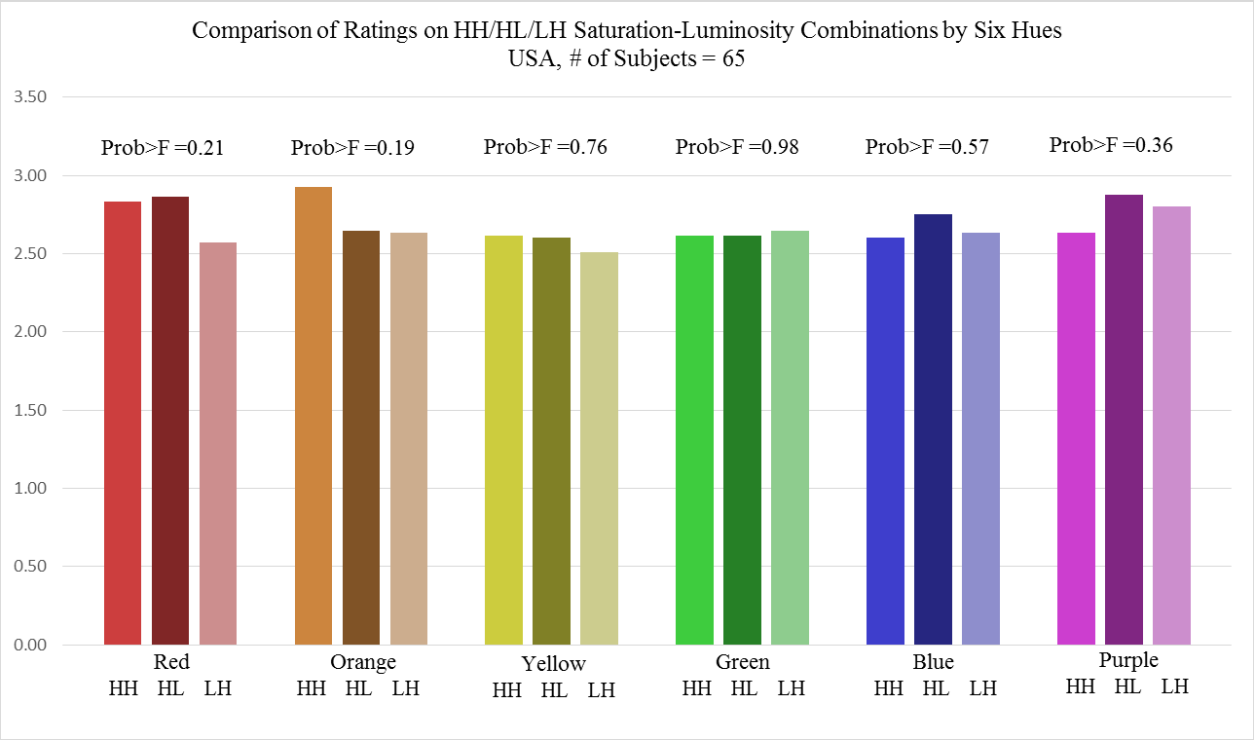
Panel B: Pearson Correlation Coefficients between Hue Preferences and Bids in the Three Countries

Shanghai, China (N=966)		Tilburg, the Netherlands (N=1050)		Tucson, U.S.A. (N=774)	
Coefficient	0.15	Coefficient	0.24	Coefficient	0.20
P-Value	<0.0001	P-Value	<0.0001	P-Value	<0.0001

Online Appendix VIII Saturation-Luminosity Variations

These two graphs report the comparisons of ratings on HH/HL/LH Saturation-Luminosity combinations for each of the six hues of the single-color Mark Rothko paintings in experiments performed in the Netherlands and the U.S. A rating of 1 signifies a strong dislike, a rating of 2 expresses a dislike, a rating of 3 is the neutral stance, a rating of 4 means a liking, and a rating of 5 represents a strong liking. The bar height indicates the average of the ratings on the corresponding Hue-Saturation-Luminosity as labeled below. The joint F-tests of whether the three rating averages are equal within each hue are reported as above the corresponding hues.




Comparison of Ratings on HH/HL/LH Saturation-Luminosity Combinations by Six Hues
USA, # of Subjects = 65
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Prob>F =0.21
Prob>F =0.19
Prob>F =0.76
Prob>F =0.98
Prob>F =0.57
Prob>F =0.36
Red
HH HL LH
Orange
HH HL LH
Yellow
HH HL LH
Green
HH HL LH
Blue
HH HL LH
Purple
HH HL LH

Online Appendix IX Predicted Emotions and Single-color Abstract Art Valuation

This table reports results of a two-stage model. In the untabulated first stage, we regress the emotion pleasure (arousal) on the rating of the corresponding hue (from the exit questionnaire). In the second stage, we regress Bid, Purchase Intention (PI), and Rank on the predicted emotions $\widehat{Pleasure}$ and $\widehat{Arousal}$ from the first stage.

Dep. Var.:	Model 1 Bid			Model 2 PI			Model 3 Rank		
	CHN	NLD	USA	CHN	NLD	USA	CHN	NLD	USA
$\widehat{Pleasure}$	9.559***	10.02***	10.76***	1.059***	0.720***	0.692***	1.720***	2.033***	2.088***
	(1.938)	(1.073)	(1.745)	(0.134)	(0.0640)	(0.0860)	(0.251)	(0.171)	(0.235)
$\widehat{Arousal}$	-0.850	-0.350	-2.607*	-0.0418	-0.0264	0.00846	-0.312	-0.262	-0.515**
	(1.711)	(1.187)	(1.374)	(0.123)	(0.0640)	(0.0680)	(0.231)	(0.183)	(0.229)
Constant	-18.61**	-21.70***	-16.07**	-1.407***	-0.466	-0.624*	-2.216**	-3.205***	-2.927***
	(7.647)	(4.470)	(6.437)	(0.488)	(0.305)	(0.335)	(0.920)	(0.727)	(0.867)
Observations	928	1,050	774	928	1,050	774	928	1,050	774
R-squared									
Number of Subjects	161	175	129	161	175	129	161	175	129
Subject FEs	YES	YES	YES	YES	YES	YES	YES	YES	YES

Online Appendix X Predicted Emotions and Dual-color Abstract Art Valuation

This table reports results of a two-stage model. In the untabulated first stage, we regress the emotion measurement of pleasure (arousal) on the ratings for the corresponding two constituent hues (from the exit questionnaire). In the second stage, we regress Bid, Purchase Intention (PI), and Rank on the predicted emotions $\widehat{Pleasure}$ and $\widehat{Arousal}$ from the first stage.

Dep. Var.:	Model 1 Bid	Model 2 PI	Model 3 Rank
$\widehat{Pleasure}$	7.283***	0.686***	1.875***
	(0.933)	(0.0579)	(0.169)
$\widehat{Arousal}$	-0.316	-0.0210	0.142
	(1.122)	(0.0682)	(0.232)
Constant	-12.21**	-0.171	-3.946***
	(4.803)	(0.309)	(1.018)
Observations	2,790	2,752	2,790
R-squared			
Number of Subjects	465	465	465
Subject Fes	YES	YES	YES

Chapter 3. Provenance in Art Markets

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ABSTRACT

This paper studies the associations between provenance information and paintings' sale probability, price, and return. We collect provenance data and apply textual analysis to categorize it into information relating to pedigree (ownership chains relating buyers to artists), exhibition history (museums, art fairs, cultural cities), literature coverage, and authentication (physical and non-physical proof of authenticity by artists, experts). We find that provenance information on average is associated with increases the artwork's probability of being sold by 3% and price premium by 30% after controlling for artwork characteristics (such as topic, authenticity), artist, time, and auction house fixed effects. In addition, the incremental provenance for the pair of the repeat sales has a positive impact on artwork return.

Keywords: Auction; art investment; cultural economics.

JEL Code: D44, G20, G11, Z11

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1. Introduction

Financial decision making requires not only an assessment of the risk-return trade-off, but also an act of trust that the information is reliable and that the overall system is fair (Guiso, Sapienza, and Zingales (2008); Sato (2014)). Trustworthy and reliable information disclosure is highly appreciated and widely utilized in this process. Investors rely on audit reports to evaluate and model target companies. Credit rating agencies regularly issue credit ratings to summarize the overall quality of the underlying assets. Reliable information is also important in art markets although this market is different from the traditional financial market in three aspects. First, there are some common practices regarding what information to disclose to potential buyers but the discrepancies are much larger due to the lack of regulation. One can obtain artist information, physical attributes, and transaction records of a collective good as well as provenance including pedigree, exhibition history, literature coverage, and authentication. Common sources are catalogues prepared by auction houses, art experts or exhibitors.

Second, the art market is illiquid and opaque. Only 2% of past sales will reenter the auction market and the average repeat sales period is about 7 years (Renneboog and Spaenjers (2013)). There is no continuous auction market for price formation and negative information is not timely priced due to the lack of short selling possibilities. The buyer and sellers are anonymous in most cases and the reserve prices are usually not revealed. For valuation purposes, as there is no fundamental value of an art piece, one has to rely on hedonic regressions which translate various characteristics into financial value.

Third, the market is affected by fakes and forgeries despite the fact that any art piece is unique as there are no exact same paintings nor prints. A former director of the MoMA (the Museum of Modern Art in New York City) once revealed that up to 40% of the high end art market consists of forgeries (Thompson (2010)). Determining the authenticity is essential in art valuations (Bocart

and Oosterlinck (2011)). Application of thorough technical inspections may help, while digesting the textual information of provenance relating to an art piece is intuitive and useful.

The art auction market is an important alternative financial market. High-net-worth individuals (HNWIs) hold on average 9% of their investment portfolios in art and other types of collectibles (such as Bordeaux wines, classic cars, superior watches, etc.). The total value of collectibles held by HNWIs is estimated at more than US$ 4 trillion (Deloitte, 2013). Purchases of art through auction houses and internet auctions have grown rapidly over the past two decades (Deloitte, 2014, 2016) and global art sales exceeded US$ 40 billion in 2015 and 2016 (Pownall, 2017). The relevant literature in finance has focused on the risk-return relationship of art (Mei and Moses (2002), Renneboog and Spaenjers (2013), Korteweg, Kräussl, and Verwijmeren (2016), Lovo and Spaenjers (2018)), its macro-economic market drivers (Goetzmann, Renneboog, and Spaenjers (2011), sentiment and hype (Pénasse, Renneboog, and Spaenjers (2014)), and whether behavioral anomalies such as anchoring (Beggs and Graddy (2009), Graddy et al. (2015)) appear in the art market. However, none of these studies focus on the more fundamental question of how information disclosure and trust play a role in this market in a direct approach and very few studies exit on the effects of authenticity or counterfeits (Bocart and Oosterlinck (2011)).

In particular, textual analysis has been proven useful in picking up influential factors among non-numeric information in accounting and finance (Li (2010), Adams, Akyol, and Verwijmeren (2018)). In this paper, we collect provenance data from art auctions, build up our own dictionary, and apply textual analysis to disentangle it into four categories: pedigree, exhibition history, literature coverage, and authentication. The first category, pedigree, is the ownership chain from the artist to the buyer. It also contains information about inheritance within families as collection. Pedigree is like a biography of an art piece and ideally renders details from the hands that made to the hands that now hold it. It adds traceability and credibility to an art piece. We compose comprehensive lists of nobility and royalty, successful businesspersons, influential politicians,

celebrities, and other prominent names. String searches are conducted within the pedigree information. As these buyers may have different sources of art expertise to help them in acquiring arts, such real purchases reveal their authenticity opinions. The second category, exhibition history, documents the past exhibitions in v museums, art fairs, and important cultural cities. Prominent exhibitions such as famous museums or biennales usually impose high acceptance standards on art quality and do not tolerate (suspicious) counterfeits. Prominent exhibitions can serve as a filter on authenticity as well as quality and popularity indicator. The third category, literature coverage, offers books, catalogues, and scholarly articles covering the art piece. The most important reference work for art is the catalogue raisonné, which includes all the known artworks by an artist. The fourth category, authentication, provides physical or non-physical proof of authenticity issued by the artist, the artist's close family, art experts, or other relevant parties.

By analyzing the above provenance measures, we improve the explaining power of hedonic regression models. We study the economic impact of various detailed levels of provenance variables on 1) the probability that a work of art is sold in an auction, 2) the price of the artwork, 3) the return on art. We find that provenance information on average is associated with an increase on the probability of being sold by 3% and a price premium by 30% after controlling for artwork characteristics (such as topic and authenticity), and artist, time and auction house fixed effects. In addition, the incremental provenance of the repeat sales has a positive impact on the artwork returns. It's noteworthy that in a subsample analysis by auction sizes, the coefficient of authentication among big auction houses is much smaller compared to that among small auction houses. We interpret that authentication has substation effects for lower reputation of small auction houses (see infra). We contribute to the literature in three aspects. First, we investigate the economic impact of information disclosure in a unique in a direct way. Second, we add a set of important variables into the hedonic regression model. These variables are constructed from textual information of provenance untouched in literature and this method can be used in other illiquid or non-standardized financial market. Third, we add to the literature on cultural economics

by revealing the important role of provenance in sales realization, valuation, and repeat sales return. We recognize that the correlations found in this paper is still far from convincing in establishing causality.

The paper proceeds as following. Section 2 describes methodology and data. Section 3 documents empirical results. Sections 4 concludes.

2. Methodology and data

2.1 Methodology

2.1.1 Hedonic price regression

To investigate the provenance effects on price, we start with hedonic price regression. The main advantage of the hedonic model is that information on all observed transactions is included. Our model relates the natural logs of real USD prices to provenance variables, while controlling for a wide range of hedonic characteristics:

$$\ln(P_{it}) = \alpha + \sum_{m=1}^{M} \beta_m X_{mit} + \sum_{t=1}^{T} \gamma_t D_{it} + \sum_{p=1}^{P} \beta_p Pedigree_{pit}$$

$$+ \sum_{l=1}^{L} \beta_l Literature_{lit} + \sum_{e=1}^{E} \beta_e Exhibition_{eit} + \sum_{a=1}^{A} \beta_n Authentication_{ait} + \varepsilon_{it} \quad (1),$$

where P_{it} represents the price of art object i at time t, X_{mit} is the value of characteristic m of item i at time t, and D_{it} is a time dummy variable that equals one if object i is sold in period t (and zero otherwise). $Pedigree_{pit}$ is the value of pedigree characteristic p of item i at time t, $Literature_{lit}$ is the value of literature characteristic l of item i at time t, $Exhibition_{eit}$ is the value of exhibition characteristic e of item i at time t, $Authenticaiton_{ait}$ is the value of authentication characteristic a of item i at time t. The coefficients β_m reflect the attribution of a relative shadow price to each of the m characteristics, and the coefficients γ_t reflect the time trend, which can be used to construct an art price index. The coefficients β_n reflect the provenance

impacts on prices. We will describe all the hedonic and provenance variables in Data and variables section.

2.1.2 Hedonic linear probability regression

In addition to hedonic price regression, we are also interested in the impacts of provenance information on the probability of being sold. The dependent variable in equation (2) is whether or not the art object was sold, and the independent variables coincide with those of Equation (1):

$$Prob(sold_{it}) = \alpha + \sum_{m=1}^{M} \beta_m X_{mit} + \sum_{t=1}^{T} \gamma_t D_{it} + \sum_{p=1}^{P} \beta_p Pedigree_{pit} +$$
$$+ \sum_{l=1}^{L} \beta_l Literature_{lit} + \sum_{e=1}^{E} \beta_e Exhibition_{eit} + \sum_{a=1}^{A} \beta_n Authentication_{ait} + \varepsilon_{it} \qquad (2).$$

2.1.3 Repeat sales returns

Another interesting question is whether the provenance information affects the returns of artworks. We identify repeat sales of an art object and examine whether the incremental changes of provenance happening between two sales have an impact on returns. The dependent variable r_{it} in Equation (3) is the annualized return of the repeat sales and we include the same hedonic control variables as in Equations (1) and (2). $Provenance_{ni(t-k)}$ is the value of provenance characteristic *n* of repeat sale item *i* at time *t-k, and* $Provenance_{nit}$ is the value of provenance characteristic *n* of repeat sale item *i* at time *t.* $Provenance_{nit} - Provenance_{ni(t-k)}$ captures the changes of provenance for the same painting from time *t-k* to time *t.* The coefficients δ_n reflect the incremental provenance effects on the returns of artworks:

$$r_{it} = \alpha + \sum_{m=1}^{M} \beta_m X_{mit} + \sum_{n=1}^{N} \beta_n Provenance_{ni(t-k)}$$
$$+ \sum_{n=1}^{N} \delta_n (Provenance_{nit} - Provenance_{ni(t-k)}) + \varepsilon_{it} \qquad (3).$$

We will describe all the hedonic and provenance variables in next subsection (Data and variables).

2.2 Data and variables

We focus on the market for oil paintings, watercolors, and drawings, which comprises the largest part of the auction market of fine arts. We collect all relevant transactions from 2007 to 2015 with provenance information in the online database *Blouin Art Sales Index*. Our dataset consists of 1,812,807 transactions of which 1,195,640 objects (65.96%) were sold at the auction. The dataset covers art sales of more than 70,000 artists in auctions held at in 608 auction house (branches) all over the world. Our sample period starts in 2007 because the information on provenance and buy-ins (i.e., items that do not reach the (undisclosed) reserve price and remain unsold) is of poor quality in the earlier years. The average (median) hammer price in our sample is about USD 53,142 (USD 3,400) and the standard deviation is about USD 638,181. For each observation, we have all the artists', artworks', and transactions' characteristic such as artist name, title of the art object, medium (oil/acryl, watercolor, print), size, attribution, creation year, being signed and/or dated by the artist, sold or not, hammer price or total buyers' payment, lot number, low and high estimates, auction date, auction house, and also the provenance information. For the cases where the total buyer's costs is given, we deduct the buyer's commission and adjust the prices to hammer prices. We put all hammer prices in deflated USD setting 2007 as the basis year. We partition the provenance information into four dimensions: pedigree, exhibition, literature, and authentication. We apply textual analysis to the provenance text and categorize each dimension into tens of subfields, which will be discussed in provenance variables subsection.

2.2.1 Classic hedonic variables

We follow Renneboog and Spaenjers (2013) and include all the classic hedonic pricing variables as control variables in our regressions. Our hedonic regressions include a number of

attributes related to the artist, the work, and the transaction. The descriptive statistics for the hedonic variables are in Table 1.

[Insert Table 1 about here]

Artist characteristics. We include artist fixed effects and a dead artist dummy. The former captures each artist's uniqueness and reputation. The dummy variable Deceased, which equals one if the latter captures the effect that the prices for artworks increase after the death of an artist as a consequence of the supply shock. In our dataset, 76.68% of the sold paintings were from deceased artists.

Artwork characteristics. We consider a wide range of price-determining variables that capture the attribution, authenticity, the medium, the size, and the topic of the work of art:

- Attribution. Six levels of attribution are used in the auction world: Attributed (to), Studio (of), Circle (of), School (of), After, and (in the) Style (of).[1] About 3.38% of the observations in our sample carry such an attribution.
- Authenticity. We include Signed, Dated, and Inscribed variables. About 80.41% of artworks are signed, about 36.28% are dated, and about 11.38% are inscribed.
- Medium. We introduce dummies for the different medium categories: Oil, Watercolor, and Drawing. About 68.13% of the transactions are oil paintings, 20.48% are watercolors, and 11.39% are drawings.
- Size. The height and width (in centimeters) are represented by Height and Width (with squared values Height_2 and Width_2).

[1] These dummy variables indicate that an artwork is made by 1) attributed to the artist, 2) from the studio of the artist, 3) from the circle of the artist, 4) from the school of the artist, 5) after the artist, or 6) in the style or manner of the artis, respectively.

- Topic. As the aesthetic and financial appreciation can depend on the painting's topic, we categorize the paintings based on the keywords of their titles. In this process, we use keywords in 7 languages most used in art auction world (and its catalogues): English, Dutch, French, German, Italian, Spanish, and Portuguese. We have 13 categories: Abstract, Animals, Landscape, Seascape, Urbanscape, Nude, People, Self Portrait, Portrait, Religion, Still Life, Study, and Other Topics. Untitled is used as the omitted benchmark in our regressions.

Transaction characteristics. We include dummies that indicate the timing of the sale, and the reputation and location of the auction house:

- Year and month. We control the sessional auction effects, as the most important auction seasons are the spring (May and June) and the autumn (November and December).
- Auction houses. We distinguish among different fine art auction houses based on reputation/size. For Sotheby's and Christie's, we introduce dummy variables for their London, New York, and other branches (e.g., Sotheby's London, Sotheby's New York, and Sotheby's Other Branches). For two other important British auction houses, Bonhams and Phillips, we distinguish between their London sales rooms and other branches (e.g., Bonhams London and Bonhams Other Branches). We also create two dummies to account for the sales by important (large or middle sized) European and American auction houses (Auction European and Auction American) following the same standards in Renneboog and Spaenjers (2013). The classification details is in the Appendix.

2.2.2 Provenance variables

We apply textual analysis to identify and categorize provenance information. We classify the provenance information into four dimensions: pedigree, exhibition, literature, and authentication. As shown in Table 1, we have 14.20% observations with pedigree information, 3.74% with

exhibition information, 4.02% with literature information, and 3.89% with authentication information.

The first dimension is **pedigree,** which refers to ownership chains by identifying past owners. For example, the painting may have been in the collection of prominent collectors, royal and noble families, wealthy families, CEOs, influential people (Time 100), celebrities (such as athletes, actors, singers, etc.). If an uninterrupted ownership chain between the artist and the current owner can be traced, the artwork has a higher probability of being authentic, such that it may trade at a premium. It is also possible that a glamour premium is paid for a painting owned by a famous individual (e.g., a superstar, a TV host) has once owned the painting (e.g., Elton John, Oprah Winfrey). It should be noted that in such cases, disentangling glamour effects and artistic quality (or authenticity) is difficult as the buyer may not just be keen to own a painting previously owned by a celebrity but may trust that celebrity's taste or the fact that she is (wealthy enough to be) well advised when she originally purchased the painting. Ennobling a work's provenance can turn an ordinary object into an extraordinary one, and a moderately valuable object into a supremely valuable object.

Besides, we examine ownership chain credibility in that we study whether the painting was acquired directly from the artist, from the artist's family, from the sitter or has uninterrupted information on the descent of the painting through the generations. If the painting is directly purchased from the artist, its provenance emits as a strong signal of the painting's authenticity. We also check whether paintings were sold through its ownership history by one or more prominent auction houses or prominent dealers. In this respect, we consider both historic and contemporary names. In order to apply the textual analysis on pedigree, we build a name's list from more than 150 databases and sources that are included in the Appendix and Online Appendix. The variables relevant to pedigree dimension are as following.

- Past ownership: Prominent Collector, Royal / Noble, Wealthy Families, CEO, Time 100, Celebrity, and Athlete.
- Descendance: Direct from Artist, From Artist Family, From Sitter, and Descent.
- Past sale channel: Sold at Sotheby's and Christie's, Sold at Bonhams and Phillips, Sold at Historic Auction Houses, Sold at Other Important Auction Houses, and Prominent Dealer.
- Other Collection: Anonymous Corporate Collection, Anonymous Private Collection, and Pedigree Other (unclassified pedigree information).

The descriptive statistics for the provenance variables are in Table 2. We have 256,560 observations with pedigree information and the average text length is 104 letters. Among all the observations with pedigree information, about 2.07% of the paintings were once part of a prominent private (anonymous) collection, 5.75% in the collection of prominent dealers, 2.39% of royal or noble collectors, 0.68% of wealthy collectors, 0.06% of CEO collectors, 0.08% of Time 100 influential people, 0.2% of celebrities, and 0.12% in the collection of famous athlete collectors. For the owner credibility, about 10.50% observations with pedigree information can be traced back to the very origin, namely a purchase directly from the artists, 5.29% were acquired from the artists' families, and 0.33% from the sitters (the persons pictured in the artwork), and 9.81% contain descendance information in the pedigree text. Regarding the previous sales records, about 15% of observations with pedigree information were sold by Sotheby's and Christie's at one point in the painting's history, 0.9% by Bonhams and Phillips, 1.33% by historically important auction houses, and 1.30% at other important auction houses.

[Insert Table 2 about here]

We label our second dimension as **exhibition.** We categorize exhibition records into: prominent exhibition, prominent art fair, prominent museum, exhibition in culture city, etc. Past exhibitions may vet the painting because the exhibited paintings are often examined by experts

and curators reflect on the position of the painting in the total oeuvre of an artist or in an artistic ear. Therefore, an often exhibited painting may trigger a premium in the art market. The exhibition variables include Prominent Exhibition, Prominent Art Fair, Prominent Museum, Other Museum, Culture City, and Gallery Exhibition.

We have 67,713 observations with exhibition information and the average text length is 209 letters. On average they are exhibited twice. Among all the observations with exhibition information, about 6.20% were at least once exhibited at prominent exhibition events, 0.39% at prominent art fair, 17.20% at prominent museums, 29.90% at other museums, 74.10% at culture cities, and 14.90% at galleries.

The third dimension is **literature**. We consider whether the artworks are included in the catalogue raisonné which offers a comprehensive listing of all the known artworks of the artist, are illustrated on the cover page of art books, or whether the literature is published by an authoritative press (e.g. a university press). The literature variables include Catalogue Raisonné, Cover Page, Illustration, Authoritative Press, and Other Literature.

We have 72,906 observations with literature information and the average text length is 242 letters and the average record number is about 1.53. Among all the observations with literature information, about 15.70% of the observations are illustrated in the Catalogue Raisonné, 1.66% are on the cover pages of books, 45.90% are illustrated in books, and 1.15% are in the books published by authoritative presses.

The fourth dimension is **authentication**. We consider two aspects: 1) the person who has issued the authentication (such as the artist, artist family, associations[2], experts, or other parties) and 2) what form of the authentication is (physical certificate vs. non-physical confirmation (orally or lacks physical proofs)). We have 10 variables in the authentication dimension:, Artist Physical

[2] Including artist's foudation, registry, etc. Detailed defenition see appendix.

Artist Family Physical, Association Physical, Expert Physical, Other People Physical, Artist Non-Physical, Artist Family Non-Physical, Association Non-Physical, Expert Non-Physical, and Other People Non-Physical.

We have 70,556 observations with authentication information with an average text length of 67 letters. Among all the observations with authentication information, about 31.70% of the observations have a physical authentication issued by artists, 6.16% by artists' families, 15.10% by artists' associations, 2.72% by experts, and 27.60% by other parties. In addition, about 5.31% of the observations are with non-physical authentication by artists, 2.20 % by artists' families, 4.45% by artists' associations, 2.88% by experts, and 6.15% by other parties.

In terms of correlations among provenance variables (tables untabulated), we find that the general Authentication dummy has close to zero correlation with other general Pedigree, Exhibition, and Literature dummies; the latter three general dummies exhibit moderate positive correlation between 0.35 to 0.45. On the detailed dummies within each four categories, we find very low correlations among those variables.

3. Empirical results

3.1 Provenance and prices

Table 3 shows the parameter estimates of the hedonic variables for our hedonic price regression. Eq. (1) is estimated using ordinary least squares (OLS) and the dependent variable is the natural log of the deflated hammer price in USD. For 1,111,220 sales we have complete information on all hedonic characteristics presented in the previous section. For the classic hedonic variables, we have consistent results with Renneboog and Spaenjers (2013). Artworks with attribution "style", "after", "school", "circle", "studio", and "attributed" are priced with large discounts. Signed, dated, or inscribed works tend to have higher prices. Oil paintings and watercolors are priced higher than the drawings. Furthermore, prices increase with size, up to the

point that the work becomes too large, which is indicated by the negative coefficients on the squared terms. In addition, artworks on portraits and studies are traded at a discount. Sotheby's London and Christie's London sell artworks with highest prices on average.

[Insert Table 3 about here]

The provenance variables in Column (1) are the dummy variables capturing if the catalogues offer any information on pedigree, exhibition, literature, and authentication. The presence of such information has big economic effects on the price level of artworks after controlling all the classic hedonic variables. We approximate the price impact by taking the exponent of the coefficient and subtracting one. If the artwork has any pedigree information, the price increases by 20.74%; if it has exhibition information, the price is 41.89% higher; with literature information, the price goes up by 53.54%; with authentication information, the price increases by 13.85%. We show that the literature information has the biggest impact on the price of artworks. In Columns (2) and (3), we use text length and number count variables of pedigree, exhibition, literature, and authentication, respectively, which yield significant and consistent results.

[Insert Table 4 about here]

Table 4 shows the results of the detailed elements of provenance information with all the same control variables applied in Table 3. In pedigree dimension, the past ownership such as prominent collectors, royal / noble families, wealthy families, and famous athletes has big economic effects on the price level of artworks. Artworks are on average priced 24.40% higher if once in the collection of prominent collectors. If the artwork is in the collection of royal / noble families, the price increases by 31.31%; if in the collection of wealthy families, the price increases by 42.45%; if in the collection of famous athletes, the price goes up by 50.11%. The owner credibility also matters for the price of artworks. If the artwork is purchased directly from the artist, the price increases by 13.84%; if the artwork is from the sitter, the price goes up by 11.27%; if the

artwork is with any descendance information, the price goes up by 23.63%. However, if the artwork is from the artist' family, this pedigree information does not affect the price, which suggests that buyers are not likely to pay premiums to the artwork which is from the artist' family. In addition, past sale channel also has an impact on the price of artworks. If the artwork was once sold at Sotheby's and Christie's, at the Bonhams and Phillips, at historically important auction houses, or by prominent dealers, the price goes up 23.63%, 7.11%, 10.04%, and 32.87%, respectively.

Exhibition elements also have big impacts on the price level of artworks. If the artwork was once exhibited at prominent exhibitions, the price increases 26.20%. If the artwork was exhibited at prominent museums or other museums, the price goes up by 58.90% and 20.66%, respectively. If the artwork was exhibited at culture cities, the price goes up 24.17%. However, the artwork once displayed in the prominent art fairs does not affect the price level of artworks.

Literature information is another important factor for the valuation of artworks. All the elements in the literature dimension have large economic effects. If the artwork is in the catalogue raisonné of the artist, on the cover page books, illustrated in books, or in the books published by authoritative press, the price increases by 35.74%, 52.76%, 44.20%, and 41.20%, respectively. The artworks with literature information are more likely to be masterpieces by established artists, which have higher prices in the auction markets.

Authentication information gives a signal on the authenticity of the artwork, which also helps create trust in the market. Table 4 shows that the physical authentication by experts has biggest price impact (40.72%) comparing with other issuers of authentication. For the non-physical authentication, the artist confirmation has biggest price impact (32.45%).

Besides all the classic hedonic variables, high estimates and variation of the high estimates to low estimates also provide information about the valuation of the artworks. High estimates may

have anchoring effects, which drive the price up. The estimation variation of high and low estimates indicates the uncertainty of the artworks' valuation. Therefore, we also include the high estimates and estimation variation variables in the price model. We regress the high estimates of artworks and the estimate variation on a series of hedonic variables in the first stage, respectively. In the second stage, we include the residuals of the unreported first stages as independent variables and rerun the price Equation (1).

Table 5 presents the second stage results of the hedonic price regression with high estimates residual and estimation variation residual. We have similar results when including the residuals of high estimates and estimation variation. The magnitude of provenance coefficients remains unchanged compared to Table 3. We also regress all the detailed provenance elements and we have consistent results, which is in Online Appendix.

[Insert Table 5 about here]

3.2 Provenance and probability of being sold

In this subsection, we focus on the impacts of provenance on the probability of being sold in auctions. Table 6 shows hedonic linear probability regression with the same control variables in hedonic price regression. In the linear probability regression, we include the reserve price variable because the reserve price could affect the sale results of artworks. If the artwork has a high reserve price, it is likely that the artworks will be bought in when the highest bid is lower than the hidden reserve price. We apply the low estimate as a proxy for the reserve price as auction evidence shows that the reserve price is very close to the low estimate. We have 1,707,136 observations with all hedonic information and low estimates in total.

[Insert Table 6 about here]

Column (1) of Table 6 shows that the presence of provenance information increases the probability of being sold by 2.39%. In Column (2), the provenance variables are the dummy variables if the artworks have any information in pedigree, exhibition, literature, and authentication. If the artwork has pedigree information, the probability of being sold increases by 1.73%. If exhibition information, the probability increases by 3.79%. If literature information, the probability increases by 2.50%. However, authentication information does not affect the probability of being sold. In addition, the negative coefficient of reserve price indicates that the artworks with higher reserve price tend to have lower probability of being sold.

Table 7 presents the results of linear probability regression with provenance details. In pedigree dimension, the past ownership by prominent collectors, royal / noble families, wealthy families, celebrities, and famous athletes increase the probability of being sold by 5.24%, 6.56%, 8.55%, 3.72% and 9.48%, respectively. For the descendance aspect, the artwork that is directly from the artist has 1.45% higher probability of being sold. The artwork with any descendance information increases the probability by 2.88%. However, if the artwork is from the sitter, the probability decreases by 8.92%. Regarding to past sale channel, if the artwork was once sold at sold at Bonhams and Phillips or sold at historic auction houses, the probability will be 2.77% and 1.64% lower, respectively. But if the artwork was once in the hands of a prominent dealer, the probability will be 3.77% higher.

[Insert Table 7 about here]

Exhibition elements also matter for the probability of being sold. If the artwork was once exhibited at prominent exhibitions, the probability increases by 2.63%. If the artwork was exhibited at prominent museums or other museums, the probability increases by 5.43% and 1.76%, respectively. If the artwork was exhibited at culture cities, the probability increases by 1.92%. If the artwork was exhibited at galleries, the probability increases by 4.30%. However, the artwork

once displayed in the prominent art fairs does not have an impact on the artworks' probability of being sold.

Literature information also has an impact on the artworks' probability of being sold. If the artwork is in the catalogue raisonné of the artist, on the cover page books, illustrated in books, the probability increases by 2.36%, 5.09%, and 2.07%, respectively. Physical authentication by artists or by artist' associations has positive effects on the probability. If the physical certificate was issued by the artist, the probability increases by 5.99%; if by artist' association, the probability increases by 3.48%. Interestingly, if the artwork is with non-physical authentication by artist' family, the probability will decrease by 3.12%, which indicates that the non-physical authentication by artist' family is still doubtful and not trusted by the participants in art auction markets.

3.3 Provenance and returns

In this subsection, we investigate whether provenance has an impact on the returns. We match our sample using artist name, size, title, medium, and the presence of signature and date. We have 6,647 repeat sales pairs from 2007 to 2015 with a holding period of at least half a year. We annualize the returns of repeat sales and regress the returns on the hedonic variables, the provenance variables at first sales, and the incremental changes of provenance between sales. The provenance variables at first sales control the quality of the provenance information of the artworks while the changes of provenance reflect the additional provenance of artworks happening in between the two sales. The hypothesis is that same paintings with the provenance changes may have positive impacts on returns.

Table 8 shows the return regression results. We are interested in the effects of the incremental provenance on returns. Column (1) - (3) are the full repeat sales sample and Column (4) - (6) are the repeat sales which are sold at the same auction houses. We apply the repeat sales at the same

auction houses to avoid the documentation biases across different auction houses. The provenance context formats may differ across auction houses. The results show that the changes of exhibition and literature have positive effects on the returns of artworks. The changes of pedigree and authentication do not affect the returns of artworks.

[Insert Table 8 about here]

Interestingly, for the repeat sales which are sold at the same auction houses (Column (4) - (6)), the authentication information at first sale has a negative effect on returns, which indicates that the authentication information has been overpriced in the first sale and make the returns in the second sale smaller. In addition, we also control the changes of auction houses in the full sample (Column (1) - (3)). If the artwork is sold at a bigger auction house at the second sale comparing with the auction house at the first sale, variable Auction House Upgrade equals one. If the artwork is sold at a smaller auction house at the second sale, variable Auction House Downgrade equals one. We find that the upgrade of auction house at the second sale has significant and big economic effects on the returns. The annualized returns increase by 39.84% if the artwork is sold at a bigger auction house at the second sale, which could be explained by both the quality of the artwork and the marketability of the big auction houses.

We examine the provenance details in Table 9. Column (1) is the full repeat sales sample and Column (2) applies the repeat sales sold at the same auction houses. We focus on the incremental effects of provenance information. If the artwork is in the collection of prominent collectors, exhibited at museums or exhibited at galleries between the two sales, the returns will increase. In addition, the incremental provenance effects will be much larger if the repeat sales are sold at the same auction houses.

[Insert Table 9 about here]

The negative coefficients of Catalogue Raisonné at First Sale, Authentication Physical at First Sale, and Authentication Nonphysical at First Sale in Column (2) indicate that the literature information and authentication information tend to be overpriced at the first sale and will result in lower returns at the next sale. While the positive coefficients of Owner Credibility at First Sale, Prominent Dealer at First Sale, and Museum at First Sale indicate that the artwork with owner credibility such as if the artwork is direct from artist, with prominent dealers or with exhibition history in museums tends to be undervalued at the first sale and will reach higher returns at the next sale.

3.4 Subsample analysis

The provenance information may vary by auction houses, the medium of artworks and by different artists. In this subsection, we investigate the provenance effects on subsamples by auction houses, medium, and schools and movements.

3.4.1 Auction houses

Table 10 shows that the subsamples by big and small auction houses. We define the big auction houses as Christie's, Sotheby's, and other important European and American auction houses. We control the price variations of auction houses by adding the lag average price of each auction house. We report the dummy variables of Pedigree, Exhibition, Literature, and Authentication in Table 10 and the results of provenance details can be found in the online Appendix.

Column (1) and Column (2) show that the pedigree and literature factors have bigger price impacts in big auction houses while the exhibition and authentication factors have bigger price impacts in small auction houses. It is important to note that the variables are in most cases picking up some unobservable differences in quality, and that the regression coefficients thus reflect

correlation instead of causality. The explanation could be that the artworks in big auction houses tend to have more artworks with prominent pedigree records and literature coverage. The authentication factor has less price impacts in big auction houses because big auction houses (such as Christie's and Sotheby's) have good reputations, expertise, and guarantee systems, which is a substitute for the authentication. Big auction houses use their reputations to create the trust in the market and guarantee the quality of the artworks. While for the small auction houses, the authentication is vital and has big impacts on price.

[Insert Table 10 about here]

Column (3) and Column (4) show the results of probability of being sold in big and small auction houses. The authentication factor has negative impacts on the probability in big auction houses and has positive impacts in small auction houses after controlling the price levels of the artworks. The results suggest that the authentication factor negatively affects the artworks' probability of being sold in big auction houses. The artworks with authentication information do not reduce doubts on the artwork's authenticity in big auction houses. The artworks with too much authentication information sometimes can be problematic and the buyers would have more doubts on the artwork authenticity if the items have too many certificates. The buyers trust the authenticity of the artworks in big auction houses and the authentication factor is a minor factor when the buyers consider purchasing items in big auction houses. However, the authentication factor has positive impacts on the probability in small auction houses, suggesting that the buyers will refer to the authentication information when purchasing artworks in small auction houses.

3.4.2 Medium

In this part, we repeat the hedonic regression analysis on three complementary subsamples of our data set: oil paintings, watercolors, and drawings. Table 11 presents the price regression results by medium. Column (1) - (3) show that literature factor has biggest price impacts no matter the

artworks are oil paintings, watercolors or drawings. The authentication factor plays less important role for drawings.

[Insert Table 11 about here]

Column (4) - (6) show the provenance effects on the probability of being sold. Authentication factor does not affect the probability across different mediums. Pedigree factor is less important for oil paintings comparing with watercolors and drawings.

3.4.3 Art schools and movements

Finally, we examine the provenance price impacts on different art schools and movements. We use the same classification in Renneboog and Spaenjers (2013) and classify the artists into one of the following art movements: Medieval & Renaissance; Baroque; Rococo; Neoclassicism; Romanticism; Realism; Impressionism & Symbolism; Fauvism & Expressionism; Cubism, Futurism & Constructivism; Dada & Surrealism; Abstract Expressionism; Pop; Minimalism & Contemporary.

Table 12 show the hedonic price regression results for different schools and movements. In general, provenance factors are significant for the all schools and movements. The exhibition and literature factors are significant for all schools and movements. However, the pedigree factor does not matter for Neoclassicism, Minimalism & Contemporary and the authentication factor is not significant for Medieval & Renaissance, Neoclassicism, Dada and Surrealism, and Abstract Expressionism.

[Insert Table 12 about here]

4. Conclusion

A serious problem for the art market is the lack of trust because the art market is not transparent and not efficient. In addition, there are many fakes and forgeries circulating in the market. These problems severely undermine the trust in art markets, which in turn have negative effects on the sales realization and prices in the art markets. The authenticity of artworks is fundamental in creating trust in the market and provenance can be a partial solution to the trust problem by giving signals of the artworks' authenticity. Provenance provides a historical record of its ownership and also relevant exhibition and literature information, which gives evidence of artwork authenticity. Reliable and complete provenance information provides evidence of the likelihood of an item being authentic or an item being of good quality. As a factor in establishing authenticity, thorough and trustworthy provenance information builds up trust in the art market and adds value to the artworks, while the absence of a provenance record raises questions about the attribution or authenticity of artworks, which negatively affects the work's valuation. Furthermore, a distinguished or glamour provenance, recording the work in the collection of a prominent owner or collection, has a positive impact on the artwork's value.

Accurate provenance information is a fundamental prerequisite for pricing but the provenance factor is rarely studied in the literature. The principal reason is that provenance information is difficult to price. Therefore, the pricing of provenance is not systematized. The valuation process of experts and buyers always depends on their experiences and is sometimes swayed by emotions. Previous studies frequently apply the hedonic model to disentangle determinants of prices of artworks by a wide range of value determining characteristics while the essential provenance factor remains missing.

In this paper, we investigate the effects of provenance on sales realization, price levels, and returns of artwork by applying textual analysis to a dataset of about two million paintings and works on paper. We show that provenance information (including pedigree, exhibition, literature

and authentication) matters for the sales realization, prices and returns of artworks. We find that provenance information on average is associated with increases the artwork's probability of being sold by 3% and price premium by 30% after controlling for artwork characteristics (such as topic, authenticity), artist, time, and auction house fixed effects. In addition, the incremental provenance for the pair of the repeat sales has a positive impact on art return. In conclusion, we study the economic effects of the elements in the provenance information, which can also be applied to other markets which are not liquid and not transparent. The extensive hedonic models with provenance factors can help to better understand and forecast prices and can be applied to alternative investment markets.

Appendix – Variable definitions, sources and string searches[3]

Other Important European Auction Houses	*Auction European:* The category includes all sales by: Lyon & Turnbull (Scotland), Francis Briest / Artcurial Briest (France), Ader, Picard & Tajan / Ader & Tajan / Tajan (France), Bruun Rasmussen (Denmark), Dorotheum (Austria), Koller (Switzerland), Lempertz (Germany), Neumeister (Germany), Finarte (Italy), Bukowskis (Sweden), Stockholms Auktionsverk (Sweden).
Other Important American Auction Houses	*Auction American:* The category includes all sales by: Butterfields (until 2002), Swann Auction Galleries, Skinner, Doyle New York, Freeman's, Leslie Hindman.
Pedigree	*Past ownership* - **Prominent Collector:** Sources: various lists from artnet The World's Top Art Collectors, Forbes Top Billionaire Art Collectors and Grove Art Online People List,etc; 3885 names[4] in total. - **Royal / Noble:** Sources: textual analysis by searching the royal and noble ranks; 364 ranks and titles in total. - **Wealthy Families:** Sources: lists from Forbes World's Billionaires and Contemporary Wealthiest Family list; 8479 names in total. - **CEO:** Sources: various sources such as Business Week, Financial World, Chief Executive, Forbes, Industry Week, Morningstar, Time Magazine, CNN, Electronic Business Magazine, Ernst & Young, The Finance Monthly, Harvard Business Review, The New York Times, Fortune, etc.; 2703 names in total. - **Time 100**: Sources: Time 100 lists of Titans, Pioneers, Artists, Leaders and Icons and Time 100 Persons of The 20 Century; 3519 names in total. - **Celebrities**: Sources: Top 1000 Actors/actresses/directors/producers in IMDb; famous TV hosts and personalities; 6255 names in total. - **Athletes**: Sources: world champions and superstars of sports such as Golf, Basketball, Tennis, Soccer, Baseball, Motorsport, Cricket, and Hockey; 4872 names in total. *Descendance* - **Directly from Artist:** String search examples: from artist; from the artist; directly from artist; directly from the artist; by artist; by the artist; gift(s) (courtesy / donation(s) / goodwill(s) / bequest(s) / endowment(s) / present(s)) of (the) artist. - **From Artist Family:** String search examples: by descent (by inheritance / estate / legacy / inherited / descended / collection) from artist (the artist / by artist / by the artist / of artists / of the artist / from painter / from the painters); artist's (artist`s / artist's / artist‘s) + family (son / daughter / wife / husband / partner

[3] We only list major souces of the name lists in the Appendix; the full lists are in the online Appendix.

[4] We create various name patterns for each prominent name in our lists such as middle names and initials.

Pedigree (continued)	/ spouse / girlfriend / boyfriend / widow / brother / sister / sibling / cousin / grandson / granddaughter / uncle / aunt / nephew / niece / heirs / heir / grandnephew / grandniece). - **From Sitter:** String search examples: sitters; sitter; from sitter; from the sitter; from sitters; from the sitters. - **Descent:** String search examples: descent; descended; inheritance; inherited. *Past sales* - **Sold at Sotheby's and Christie's:** String search examples: Christie; Sotheby - **Sold at Bonhams and Phillips:** String search examples: Bonhams; Phillips - **Sold at Historic Auction Houses:** String search examples: Achenbach; Anderson & Garland; Thomas Dodd; F. Dörling; Dorotheum; Dowell's; Hôtel Drouot; Galerie Fischer; Edward Foster & Son; Messrs Foster; Frederik Muller & Co.; John Gerard; Gerard-Tasset-Juge; Gilhofer & Ranschburg; Goesin-Verhaeghe; Pierre François; Paul Graupe; Heinrich Hahn; Hugo Helbing; Galerie Helbing; Internationales Kunst Auktionshaus; George Jones; Albert Kende; S. Kende; Thomas King; August Klipstein; Galerie Kornfeld; Knight Frank & Rutley; W. S. Kündig; Hans W. Lange; Langford; Mathias Lempertz; Heinrich Lempertz; Gallery Lempertz Contempora; Venator & Hanstein; Kunsthaus Lempertz; Leo Spik; Rudolph Lepke; Bignell Marle; P. L. Mastraeten; Franz A. Menna; Corneille Moor; Morrison Mcchlery; Max Perl; Thomas Philipe; Harry Phillips; Mr. Prestage; Puttick & Simpson; William Richardson; George Henry Robins; Henry J. Robins; Robinson & Foster; Robert Saunders; Hodgson & Co; Saunders & Hodgson; Philippus Van Der Schley; James Webber Southgate; George Squibb; Squibb & Son; Rushworth, Abbott & Co; George Stanley; J. A. Stargardt; William Stewart; E. J. Terlinck; ; De Vries; Adolf Weinmüller; Munich Auction House; Benjamin Wheatley; Willis's Rooms; Winstanley & Sons; Puttick & Simpson; Stewart, Wheatley & Adlard; Wheatley & Adlard. - **Sold at Other Important Auction Houses:** String search examples: Butterfields; Lyon & Turnbull; Francis Briest; Artcurial Briest; Tajan; Bruun Rasmussen; Dorotheum; Koller; Lempertz; Neumeister; Finarte; Bukowskis; Stockholms Auktionsverk; Swann Auction Galleries; Swann Galleries; Skinner; Doyle New York; Freeman's; Freeman`s; Freeman's; Leslie Hindman. - **Prominent Dealer**: lists from artnet, Forbes and Wikipedia; 233 names in total *Other* - **Anonymous Corporate Collection:** String search: corporate collection. - **Anonymous Private Collection:** String search examples: private collection.
Exhibition	- **Prominent Exhibition:** String search examples: retrospective; rétrospective; anniversary; anniversaire; biennale; triennale; biannual; biennial; triannual; triennial. - **Prominent Art Fair:** String search examples: ARCO Madrid, Armory Show New York, Art Basel, Art Basel HK, Art Basel Miami Beach, Art Cologne, Art Miami, Art Santa Fe, ARTISSIMA, Documenta Kassel, FIAC Paris, Frieze London,

Exhibition (Continued)	Frieze New York, India Art Fair, PAN Amsterdam, TEFAF Maastricht, TEFAF New York, Venice Biennale, BRAFA Brussels - **Prominent Museum:** Sources: most important museums of paintings in important art cities; 517 museums in total. - **Culture City:** Sources: European Capital of Culture and other culture city around the world; 236 cities in total. - **Gallery Exhibition**: other unclassified exhibitions.
Literature	- **Catalogue Raisonné:** String search examples: catalogue raisonne; catalogue raisonné. - **Cover Page:** String search examples: cover. - **Illustration:** String search examples: illustration; illustrated; cover; images; image; photos; photo. - **Authoritative Press:** Sources: notable university presses and world's largest book publishers.
Authentication	- **Authentication:** String search examples: echtheitsbestätigung; gutachten; essay(s); assessment(s); opinion(s); appraisal(s); expert(s); expertise(s); report(s); mail(s); photocertificate(s); photocopy; photocopies; issued; verified; witnessed; authenticity; authentication. - **Forms-physical:** String search examples: photocertificate(s); report; written; handwritten; photocopy; photocopies; photo(s); photogrpahy; photographic; photograph; foto(s); foto's; photogrpahy; fotografische; fotographie; fotografie; fotografie; fotografien; photogrpahy; photographique; photographie(s). - **Issuers-artist:** String search examples: issued (verified / witnessed / certificates / certificate / certificate + signed / certified / authenticity / authenticity signed / authentication / authentication signed / authenticated / identified / identification / confirmed / confirmation / confirmatory information / registered / registration / registration card / registered / recorded / documentation / letter(s) / photo(s) / photo(s) signed / photograph(s) / photograph(s) signed) + by artist (by the artist / from artist / from the artist / of artist / of the artist). - **Issuers-artist family:** String search examples: son; daughter; wife; husband; partner; spouse; girlfriend; boyfriend; widow; brother; sister; sibling; cousin; grandson; granddaughter; uncle; aunt; nephew; niece; family; descendants; descendant; biographer; pupils; pupil; students; student. - **Issuers-association:** String search examples: authentication; board; estate; foundation(s); fundament; stiftung; fondation; fundación; fundação; fondazione; association; vereniging; verband; asociación; associação; associazione; committee; commissie; ausschuss. - **Issuers-expert:** String search examples: Dr; Prof; curator(s); custodian(s); professor(s); doctor(s); director(s); expert(s); expertise(s); professoren; professore; professoressa; professeur(s); professore(s); professori; profesor.

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Table 1 – Descriptive Statistics for Hedonic Variables

This table presents the descriptive statistics for the hedonic variables. Deceased equals one in case the artist is dead at the time of the sale. The attribution dummies Attributed, Studio, Circle, School, After, and Style equal one if the auction catalogue identifies the work as being "attributed to" the artist, from the "studio" of that artist, from the "circle" of the artist, from the artist's "school", "after" the artist, or "in the style of" the artist, respectively. The authenticity dummies Signed, Dated, and Inscribed take the value of one if the work carries a signature of the artist or is dated, inscribed, respectively. The medium dummies Oil, Watercolor, and Drawing indicate whether the work is an oil painting, a watercolor, or a drawing. The variables Height and Width measure the height and the width of the work in centimeters. The month dummies indicate the month of the sale. setting January as the benchmark The auction house dummies Sotheby's London, Sotheby's New York, Sotheby's Other Branches, Christie's London, Christie's New York, Christie's Other Branches, Bonhams London, Bonhams Other Branches, Phillips London, and Phillips Other Branches equal one if the sale takes place at Sotheby's London, Sotheby's New York, another branches of Sotheby's, Christie's London, Christie's New York, another branches of Christie's, Bonhams London, another offices of Bonhams, Phillips London, or another sales rooms of Phillips, respectively. Auction European and Auction American are dummy variables that equal one if the sale takes place at a large Continental European or a large American auction house, respectively (see Appendix). Pedigree, Exhibition, Literature, and Authentication are the dummy variables if the artworks have any information of pedigree, exhibition, literature, and authentication, respectively. Pedigree (Text Length), Exhibition (Text Length), Literature (Text Length) and Authentication (Text Length) are the text length of pedigree, exhibition, literature, and authentication information, respectively. Exhibition (Number Count) and Literature (Number Count) are the record number count of exhibition and literature information, respectively. For each variable, we report the number of observations (N), the mean, the standard deviation (S.D.), the minimum value, and maximum value.

	N	Mean	S.D.	Min	Max
Artist Characteristics					
DECEASED	1,812,807	0.7668	0.4228	0	1
Artwork Characteristics					
Attribution Dummies					
Attributed	1,812,807	0.0275	0.1635	0	1
Studio	1,812,807	0.0012	0.0344	0	1
Circle	1,812,807	0.0025	0.0495	0	1
School	1,812,807	0.0002	0.0142	0	1
After	1,812,807	0.0020	0.0452	0	1
Style	1,812,807	0.0004	0.0210	0	1
Authenticity Dummies					
Signed	1,812,807	0.8041	0.3969	0	1
Dated	1,812,807	0.3628	0.4808	0	1
Inscribed	1,812,807	0.1138	0.3176	0	1
Medium Dummies					

	N	Mean	S.D.	Min	Max
Oil	1,812,807	0.6813	0.4660	0	1
Watercolor	1,812,807	0.2048	0.4035	0	1
Drawing	1,812,807	0.1139	0.3177	0	1
Size Variables					
Height	1,812,807	59.4621	51.1393	1	10,000
Width	1,806,082	61.3305	73.8626	0	50,353
Topic Dummies					
Abstract	1,812,807	0.0233	0.1508	0	1
Animals	1,812,807	0.0474	0.2125	0	1
Landscape	1,812,807	0.1492	0.3563	0	1
Seascape	1,812,807	0.0426	0.2018	0	1
Urbanscape	1,812,807	0.0877	0.2828	0	1
Nude	1,812,807	0.0137	0.1161	0	1
People	1,812,807	0.0841	0.2776	0	1
Self Portrait	1,812,807	0.0033	0.0572	0	1
Portrait	1,812,807	0.0356	0.1853	0	1
Religion	1,812,807	0.0199	0.1396	0	1
Still Life	1,812,807	0.0584	0.2345	0	1
Study	1,812,807	0.0128	0.1126	0	1
Transaction Characteristics					
Month					
January	1,812,807	0.0377	0.1905	0	1
February	1,812,807	0.0516	0.2212	0	1
March	1,812,807	0.0869	0.2817	0	1
April	1,812,807	0.0774	0.2673	0	1
May	1,812,807	0.1183	0.323	0	1
June	1,812,807	0.1301	0.3364	0	1
July	1,812,807	0.0424	0.2015	0	1
August	1,812,807	0.0221	0.1470	0	1
September	1,812,807	0.0676	0.2511	0	1
October	1,812,807	0.0977	0.2968	0	1
November	1,812,807	0.1456	0.3527	0	1
December	1,812,807	0.1226	0.3280	0	1
Auction House					
Sotheby's London	1,812,807	0.0224	0.1481	0	1
Sotheby's New York	1,812,807	0.0236	0.1518	0	1
Sotheby's Other Branches	1,812,807	0.0203	0.1410	0	1
Christie's London	1,812,807	0.0153	0.1227	0	1
Christie's New York	1,812,807	0.0236	0.1519	0	1
Christie's Other Branches	1,812,807	0.0501	0.2182	0	1
Bonhams London	1,812,807	0.0103	0.1011	0	1
Bonhams Other Branches	1,812,807	0.0438	0.2047	0	1
Phillips London	1,812,807	0.0026	0.0514	0	1
Phillips Other Branches	1,812,807	0.0036	0.0600	0	1
Auction American	1,812,807	0.0316	0.1749	0	1
Auction European	1,812,807	0.1182	0.3228	0	1
Provenance Information					
Pedigree	1,812,807	0.1420	0.3490	0	1

	N	Mean	S.D.	Min	Max
Exhibition	1,812,807	0.0374	0.1900	0	1
Literature	1,812,807	0.0402	0.1960	0	1
Authentication	1,812,807	0.0389	0.1930	0	1
Pedigree (Text Length)	1,812,807	14.7200	67.950	0	9,034
Exhibition (Text Length)	1,812,807	7.8020	67.580	0	6,828
Literature (Text Length)	1,812,807	9.7240	91.230	0	22,413
Authentication (Text Length)	1,812,807	12.2900	29.630	1	6,234
Exhibition (Number Count)	1,812,807	0.0738	0.6340	0	46
Literature (Number Count)	1,812,807	0.0615	0.5670	0	150

Table 2 – Descriptive Statistics for Provenance Variables

This table presents the descriptive statistics for the provenance variables. Pedigree (Text Length) is the text length of pedigree information. Prominent Collector, Prominent Dealer, Royal / Noble, Wealthy Families, CEO, Time 100, Celebrity, and Athlete equal one if the artworks are once in the collections of prominent collectors, prominent dealers, royal / noble families, wealthy families, CEO, Time 100, celebrity, and athlete, respectively. Direct from Artist, From Artist Family, and From Sitter equal one if the artworks are acquired directly from artists, from the artists' families, and from the sitters, respectively. Descent equals one if the artworks contain any descendance information in the pedigree text. Sold at Sotheby's and Christie's, Sold at Bonhams and Phillips, Sold at Historic Auction Houses and Sold at Other Important Auction Houses equal one if the artworks are once sold at Sotheby's and Christie's, at Bonhams, Phillips, at historically important auction houses, and at other important auction houses, respectively. Anonymous Corporate Collection and Anonymous Private Collection equal one if the artworks are once in the corporate and private collections, respectively. Pedigree Other equals one if the artworks have other unclassified pedigree information. Exhibition (Text Length) is the text length of exhibition information and Exhibition (Number Count) is the number count of exhibition information. Prominent Exhibition, Prominent Art Fair, Prominent Museum, Other Museum, Culture City, and Gallery Exhibition equal one if the artworks are once exhibited at prominent exhibitions, prominent art fairs, prominent museums, other museums, culture cities, and gallery exhibitions, respectively. Literature (Text Length) is the text length of literature information and Literature (number count) is the number count of literature information. Catalogue Raisonné, Cover Page, Illustration, and Authoritative Press equal one if the artworks are illustrated in the catalogue raisonné, on the cover page of books, or in the literature which are published by the authoritative press, respectively. Other Literature equals one if the artworks contain other unclassified literature information. Authentication (Text Length) is the text length of authentication information. Artist Physical, Artist Family Physical, Association Physical, Expert Physical, and Other People Physical equal one if the artworks are with physical authentication issued by artists, by artists' families, by artists' associations, by experts and by other parties, respectively. Artist Non-Physical, Artist Family Non-Physical, Association Non-Physical, Expert Non-Physical, and Other People Non-Physical equal one if the artworks are with non-physical authentication issued by artists, by artists' families, by artists' associations, by experts and by other parties, respectively. Variables with "Number Count" indicate the number count variables instead of dummies. For each variable, we report the number of observations (N), the conditional mean, the standard deviation (S.D.), the minimum value, and maximum value.

	N	Mean	S.D.	Min	Max
Pedigree					
Pedigree (Text Length)	256,560	104	152.8	0	9,034
Prominent Collector	256,560	0.0207	0.1420	0	1
Royal / Noble	256,560	0.0239	0.1530	0	1
Wealthy Families	256,560	0.0068	0.0822	0	1
CEO	256,560	0.0006	0.0245	0	1
Time 100	256,560	0.0008	0.0289	0	1
Celebrity	256,560	0.0020	0.0446	0	1
Athlete	256,560	0.0012	0.0352	0	1
Direct from Artist	256,560	0.1050	0.3070	0	1
From Artist Family	256,560	0.0529	0.2240	0	1
From Sitter	256,560	0.0033	0.0576	0	1
Descent	256,560	0.0981	0.2970	0	1
Sold at Sotheby's and Christie's	256,560	0.1500	0.3570	0	1
Sold at Bonhams and Phillips	256,560	0.0090	0.0942	0	1
Sold at Historic Auction Houses	256,560	0.0133	0.1150	0	1
Sold at Other Important Auction Houses	256,560	0.0130	0.1130	0	1
Prominent Dealer	256,560	0.0575	0.2330	0	1
Anonymous Corporate Collection	256,560	0.0016	0.0401	0	1
Anonymous Private Collection	256,560	0.2600	0.4380	0	1
Pedigree Other	256,560	0.4250	0.4940	0	1
Prominent Collector (Number Count)	256,560	0.0213	0.1690	0	8
Prominent Dealer (Number Count)	256,560	0.0624	0.2640	0	6
Descent (Number Count)	256,560	0.1090	0.3610	0	11
Sold at Sotheby's and Christie's (Number Count)	256,560	0.1780	0.4660	0	12
Sold at Bonhams and Phillips (Number Count)	256,560	0.0092	0.0983	0	5
Sold at Other Important Auction Houses (Number Count)	256,560	0.0137	0.1230	0	3
Sold at Historic Auction Houses (Number Count)	256,560	0.0150	0.1370	0	5
Exhibition					
Exhibition (Text Length)	67,713	208.9	283.3	1	6,828
Exhibition (Number Count)	67,713	1.9760	2.6480	0	46
Prominent Exhibition	67,713	0.0620	0.2410	0	1
Prominent Art Fair	67,713	0.0039	0.0620	0	1
Prominent Museum	67,713	0.1720	0.3780	0	1
Other Museum	67,713	0.2990	0.4580	0	1
Culture City	67,713	0.7410	0.4380	0	1
Gallery Exhibition	67,713	0.1490	0.3560	0	1
Prominent Exhibition (Number Count)	67,713	0.0708	0.3050	0	18
Prominent Art Fair (Number Count)	67,713	0.0041	0.0674	0	4
Prominent Museum (Number Count)	67,713	0.2730	0.7860	0	20
Other Museum (Number Count)	67,713	0.2992	0.4579	0	1
Culture City (Number Count)	67,713	1.5740	2.1210	0	41
Literature					
Literature (Text Length)	72,906	241.8	388.4	0	22,413
Literature (Number Count)	72,906	1.5300	2.3970	0	150
Catalogue Raisonné	72,906	0.1570	0.3640	0	1
Cover Page	72,906	0.0166	0.1280	0	1
Illustration	72,906	0.4590	0.4980	0	1
Authoritative Press	72,906	0.0115	0.1060	0	1

	N	Mean	S.D.	Min	Max
Other Literature	72,906	0.4810	0.5000	0	1
Catalogue Raisonné (Number Count)	72,906	0.1690	0.4100	0	6
Cover Page (Number Count)	72,906	0.0181	0.1490	0	6
Illustration (Number Count)	72,906	0.8450	1.6170	0	89
Authoritative Press (Number Count)	72,906	0.0122	0.1180	0	4
Authentication					
Authentication (Text Length)	70,556	66.896	63.3479	6	4,101
Artist Physical	70,556	0.3170	0.4650	0	1
Artist Family Physical	70,556	0.0616	0.2400	0	1
Association Physical	70,556	0.1510	0.3580	0	1
Expert Physical	70,556	0.0272	0.1630	0	1
Other People Physical	70,556	0.2760	0.4470	0	1
Artist Non-Physical	70,556	0.0531	0.2240	0	1
Artist Family Non-Physical	70,556	0.0220	0.1470	0	1
Association Non-Physical	70,556	0.0445	0.2060	0	1
Expert Non-Physical	70,556	0.0288	0.1670	0	1
Other People Non-Physical	70,556	0.0615	0.2400	0	1

Table 3 – Baseline Hedonic Price Regression Results

This table presents the baseline hedonic price regression results. Eq. (1) is estimated using OLS. The dependent variable is the natural log of deflated hammer price in USD. In Column (1), provenance variables are the dummy variables if the artworks have any information of pedigree, exhibition, literature, and authentication, respectively. Column (2) uses the natural log of text length of pedigree, exhibition, literature, and authentication information. Column (3) uses the number count variables of exhibition, literature, and the dummy variables of pedigree and authentication. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors (S.E.) are reported in parentheses and clustered at the auction branch level.

VARIABLES	(1) dummy	(2) length	(3) number
Artist Characteristics			
Deceased	0.1900***	0.1916***	0.1912***
	(0.0211)	(0.0211)	(0.0210)
Artwork Characteristics			
Attribution			
Attributed	-0.8278***	-0.8207***	-0.8339***
	(0.0360)	(0.0357)	(0.0362)
Studio	-0.7771***	-0.7638***	-0.7775***
	(0.0930)	(0.0893)	(0.0960)
Circle	-0.9265***	-0.9042***	-0.9337***
	(0.0980)	(0.0928)	(0.0976)
School	-0.9362***	-0.9096***	-0.9087***
	(0.1010)	(0.0964)	(0.0977)
After	-1.5346***	-1.5103***	-1.5307***
	(0.1212)	(0.1136)	(0.1217)
Style	-1.3193***	-1.2851***	-1.3213***
	(0.1053)	(0.0994)	(0.1044)
Authenticity			
Signed	0.0746**	0.0746**	0.0737**
	(0.0309)	(0.0302)	(0.0311)
Dated	0.1602***	0.1584***	0.1588***
	(0.0133)	(0.0131)	(0.0134)
Inscribed	0.0337***	0.0307***	0.0351***
	(0.0111)	(0.0112)	(0.0112)
Medium			
Oil	1.3427***	1.3368***	1.3422***
	(0.0296)	(0.0288)	(0.0292)
Watercolor	0.5227***	0.5205***	0.5207***
	(0.0310)	(0.0305)	(0.0307)
Size			
Height	0.0056***	0.0056***	0.0056***
	(0.0003)	(0.0003)	(0.0003)
Width	0.0049***	0.0049***	0.0049***
	(0.0003)	(0.0003)	(0.0003)
Height_2	-0.0000***	-0.0000***	-0.0000***
	(0.0000)	(0.0000)	(0.0000)
Width_2	-0.0000***	-0.0000***	-0.0000***

VARIABLES	(1) dummy	(2) length	(3) number
	(0.0000)	(0.0000)	(0.0000)
Topic			
Abstract	0.0341	0.0334	0.0302
	(0.0334)	(0.0338)	(0.0334)
Animals	0.0303	0.0298	0.0325
	(0.0350)	(0.0354)	(0.0348)
Landscape	0.0805	0.0800	0.0825
	(0.0534)	(0.0538)	(0.0532)
Seascape	0.1165***	0.1159***	0.1194***
	(0.0326)	(0.0328)	(0.0324)
Urbanscape	0.1679***	0.1667***	0.1701***
	(0.0288)	(0.0291)	(0.0287)
Nude	0.0086	0.0094	0.0102
	(0.0340)	(0.0343)	(0.0338)
People	0.0489*	0.0482	0.0510*
	(0.0292)	(0.0295)	(0.0291)
Self Portrait	0.2407***	0.2353***	0.2494***
	(0.0433)	(0.0436)	(0.0438)
Portrait	-0.1370***	-0.1366***	-0.1349***
	(0.0278)	(0.0280)	(0.0276)
Religion	0.0825***	0.0801***	0.0856***
	(0.0306)	(0.0309)	(0.0306)
Still Life	0.0847**	0.0838*	0.0875**
	(0.0431)	(0.0434)	(0.0429)
Study	-0.1375***	-0.1374***	-0.1354***
	(0.0262)	(0.0264)	(0.0262)
Other Topic	0.1497***	0.1486***	0.1535***
	(0.0453)	(0.0458)	(0.0451)
Transaction Characteristics			
Auction House			
Sotheby's London	0.9789***	0.9438***	1.0046***
	(0.0389)	(0.0398)	(0.0367)
Sotheby's New York	0.7814***	0.7450***	0.7952***
	(0.0459)	(0.0466)	(0.0440)
Sotheby's Other Branches	0.5620***	0.5517***	0.5885***
	(0.0486)	(0.0468)	(0.0488)
Christie's London	0.9361***	0.8892***	0.9625***
	(0.0421)	(0.0431)	(0.0379)
Christie's New York	0.4944***	0.4579***	0.5081***
	(0.0358)	(0.0372)	(0.0337)
Christie's Other Branches	0.3139***	0.2973***	0.3392***
	(0.0383)	(0.0365)	(0.0420)
Bonhams London	0.6413***	0.6224***	0.6517***
	(0.0276)	(0.0277)	(0.0271)
Bonhams Other Branches	0.0447	0.0338	0.0489
	(0.0627)	(0.0625)	(0.0634)
Phillips London	0.4901***	0.4865***	0.5115***
	(0.0757)	(0.0757)	(0.0767)
Phillips Other Branches	0.4337***	0.4230***	0.4611***
	(0.1366)	(0.1323)	(0.1368)

VARIABLES	(1) dummy	(2) length	(3) number
Auction American	-0.0966**	-0.0968**	-0.0987**
	(0.0388)	(0.0391)	(0.0387)
Auction European	0.2168***	0.2161***	0.2170***
	(0.0484)	(0.0483)	(0.0484)
	Provenance		
Pedigree	0.1885***	0.0531***	0.2379***
	(0.0170)	(0.0045)	(0.0194)
Exhibition	0.3499***	0.0734***	0.1043***
	(0.0208)	(0.0041)	(0.0066)
Literature	0.4288***	0.0869***	0.1266***
	(0.0336)	(0.0063)	(0.0054)
Authentication	0.1297***	0.0614***	0.1305***
	(0.0226)	(0.0100)	(0.0220)
Artist FE	YES	YES	YES
Year FE	YES	YES	YES
Month FE	YES	YES	YES
Observations	1,111,220	1,111,220	1,111,220
R-squared	0.7805	0.7817	0.7807

Table 4 – Hedonic Price Regression Results with Provenance Details

This table presents the hedonic price regression results with provenance details. Eq. (1) is estimated using OLS. The dependent variable is the natural log of deflated hammer price in USD. The descriptive statistics for the independent variables are shown in Table 2. Provenance variables are dummy variables in Column (1) and the corresponding price impacts (i.e., the exponent of the estimated coefficient minus one) are in Column (2). Column (3) uses number count variables of Prominent Collector, Descent, Sold at Sotheby's and Christie's, Sold at Bonhams and Phillips, Sold at Other Important Auction Houses, Sold at Historic Auction Houses, Prominent Dealer, Prominent Exhibition, Prominent Art Fair, Prominent Museum, Other Museum, Culture City, Catalogue Raisonné, Cover Page, Illustration, and Authoritative Press. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors (S.E.) are reported in parentheses and clustered at the auction branch level.

VARIABLES	(1) dummy	(2) price impact	(3) number
	Pedigree		
Past Ownership			
Prominent Collector	0.2183***	24.40%	0.1289***
	(0.0405)		(0.0239)
Royal / Noble	0.2724***	31.31%	0.2460***
	(0.0262)		(0.0275)
Wealthy Families	0.3538***	42.45%	0.3756***
	(0.0479)		(0.0660)
CEO	0.1479	15.94%	0.0016
	(0.1021)		(0.0905)
Time100	0.0841	8.77%	0.0010
	(0.0842)		(0.1065)
Celebrity	0.1288	13.75%	0.2102
	(0.1308)		(0.1492)
Athlete	0.4062***	50.11%	0.4018***
	(0.1358)		(0.1069)
Descendance			
Direct from Artist	0.1296***	13.84%	0.1319***
	(0.0142)		(0.0146)
From Artist Family	0.0070	0.70%	0.0147
	(0.0239)		(0.0236)
From Sitter	0.1068**	11.27%	0.0973*
	(0.0515)		(0.0581)
Descent	0.2121***	23.63%	0.1791***
	(0.0190)		(0.0112)
Past Sales Channel			
Sold at Sotheby's and Christie's	0.2121***	23.63%	0.1666***
	(0.0243)		(0.0220)
Sold at Bonhams and Phillips	0.0687*	7.11%	0.0458
	(0.0387)		(0.0332)
Sold at Historic Auction Houses	0.0957***	10.04%	0.0799*
	(0.0363)		(0.0409)
Sold at Other Important Auction Houses	-0.0463	-4.52%	-0.0231
	(0.0393)		(0.0346)

Prominent Dealer	0.2842***	32.87%	0.2421***
	(0.0378)		(0.0334)
Other Collection			
Anonymous Corporate Collection	0.1038**	10.94%	0.1157**
	(0.0482)		(0.0530)
Anonymous Private Collection	0.1793***	19.64%	0.1932***
	(0.0222)		(0.0230)
Pedigree Other	0.1323***	14.15%	0.1356***
	(0.0133)		(0.0132)
Exhibition			
Prominent Exhibition	0.2327***	26.20%	0.0783***
	(0.0247)		(0.0167)
Prominent Art Fair	-0.0055	-0.55%	-0.0473
	(0.0648)		(0.0601)
Prominent Museum	0.4631***	58.90%	0.2976***
	(0.0331)		(0.0174)
Other Museum	0.1878***	20.66%	0.2562***
	(0.0147)		(0.0219)
Culture City	0.2165***	24.17%	0.0830***
	(0.0147)		(0.0059)
Gallery Exhibition	0.2535***	28.85%	0.2563***
	(0.0220)		(0.0210)
Literature			
Catalogue Raisonné	0.3056***	35.74%	0.2895***
	(0.0448)		(0.0356)
Cover Page	0.4237***	52.76%	0.0868*
	(0.0513)		(0.0491)
Illustration	0.3660***	44.20%	0.1197***
	(0.0366)		(0.0069)
Authoritative Press	0.3450***	41.20%	0.2556***
	(0.0876)		(0.0868)
Other Literature	0.3186***	37.52%	0.3151***
	(0.0252)		(0.0240)
Authentication			
Artist Physical	0.0828***	8.63%	0.0821***
	(0.0262)		(0.0259)
Artist Family Physical	0.0674*	6.97%	0.0652*
	(0.0385)		(0.0384)
Association Physical	0.1199***	12.74%	0.1200***
	(0.0410)		(0.0408)
Expert Physical	0.3416***	40.72%	0.3415***
	(0.0517)		(0.0515)
Other People Physical	0.1148***	12.16%	0.1126***
	(0.0302)		(0.0300)
Artist Non-Physical	0.2810***	32.45%	0.2806***
	(0.0287)		(0.0286)
Artist Family Non-Physical	0.0039	0.39%	0.0113
	(0.0597)		(0.0543)
Association Non-Physical	0.1889***	20.79%	0.1872***
	(0.0352)		(0.0361)

Expert Non-Physical	0.1654***	17.99%	0.1670***
	(0.0482)		(0.0482)
Other People Non-Physical	0.1340***	14.34%	0.1350***
	(0.0393)		(0.0390)
Artist FE	YES		YES
Attribution	YES		YES
Authenticity	YES		YES
Medium	YES		YES
Size	YES		YES
Topic	YES		YES
Year	YES		YES
Month	YES		YES
Auction house	YES		YES
Observations	1,111,220		1,111,220
R-squared	0.7819		0.7820

Table 5 – Hedonic Price Regression Results with High Estimates and Estimate Variations

This table presents the second stage hedonic price regression results. Eq. (1) is estimated using OLS. The dependent variable is the natural log of deflated hammer price in USD. Provenance variables are dummy variables. Column (1) includes the high estimate residual from the first stage regression; Column (2) includes the estimate variation residual from the first stage regression; Column (3) includes residuals of both high estimate and estimate variation. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors (S.E.) are reported in parentheses and clustered at the auction branch level.

VARIABLES	(1)	(2)	(3)
Pedigree	0.1856***	0.1873***	0.1856***
	(0.0094)	(0.0173)	(0.0094)
Exhibition	0.3504***	0.3504***	0.3505***
	(0.0056)	(0.0214)	(0.0056)
Literature	0.4281***	0.4268***	0.4281***
	(0.0127)	(0.0339)	(0.0127)
Authentication	0.1274***	0.1294***	0.1274***
	(0.0169)	(0.0229)	(0.0169)
Residuals High Estimate	0.8804***		0.8809***
	(0.0084)		(0.0083)
Residuals Estimate Variations		-0.0015*	-0.0056***
		(0.0008)	(0.0010)
Artist FE	YES	YES	YES
Attribution	YES	YES	YES
Authenticity	YES	YES	YES
Medium	YES	YES	YES
Size	YES	YES	YES
Topic	YES	YES	YES
Year	YES	YES	YES
Month	YES	YES	YES
Auction house	YES	YES	YES
Observations	985,877	1,075,955	985,877
R-squared	0.9221	0.7832	0.9222

Table 6 – Hedonic Linear Probability Regression Results

This table presents the baseline hedonic linear probability regression results. Eq. (2) is estimated using OLS. The dependent variable is the sale results (sold / unsold). The independent variables in this equation are the same with Eq. (1). In Column (1), Provenance equal one if artworks have any provenance information (pedigree, exhibition, literature, or authentication). In Column (2), Pedigree, Exhibition, Literature, and Authentication are dummy variables if the artworks have any information of pedigree, exhibition, literature, and authentication, respectively. Column (3) uses the natural log of text length of pedigree, exhibition, literature, and authentication information. Column (4) uses the number count variables of exhibition, literature and the dummy variables of pedigree and authentication. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors (S.E.) are reported in parentheses and clustered at the auction branch level.

VARIABLES	(1) dummy	(2) dummy	(3) length	(4) number
Artist Characteristics				
Deceased	0.0262***	0.0265***	0.0267***	0.0266***
	(0.0059)	(0.0059)	(0.0059)	(0.0059)
Artwork Characteristics				
Attribution				
Attributed	-0.0991***	-0.0991***	-0.0988***	-0.0995***
	(0.0073)	(0.0074)	(0.0074)	(0.0073)
Studio	-0.1044***	-0.1020***	-0.1015***	-0.1019***
	(0.0117)	(0.0116)	(0.0115)	(0.0116)
Circle	-0.1683***	-0.1646***	-0.1633***	-0.1649***
	(0.0145)	(0.0149)	(0.0150)	(0.0148)
School	-0.1631***	-0.1603***	-0.1588***	-0.1586***
	(0.0369)	(0.0372)	(0.0373)	(0.0373)
After	-0.2075***	-0.2033***	-0.2028***	-0.2028***
	(0.0169)	(0.0167)	(0.0165)	(0.0167)
Style	-0.1443***	-0.1411***	-0.1394***	-0.1408***
	(0.0226)	(0.0229)	(0.0230)	(0.0228)
Authenticity				
Signed	0.0311***	0.0314***	0.0313***	0.0313***
	(0.0067)	(0.0067)	(0.0066)	(0.0067)
Dated	0.0285***	0.0286***	0.0284***	0.0286***
	(0.0029)	(0.0029)	(0.0028)	(0.0029)
Inscribed	0.0125***	0.0127***	0.0121***	0.0128***
	(0.0047)	(0.0046)	(0.0046)	(0.0046)
Medium				
Oil	0.1406***	0.1404***	0.1411***	0.1404***
	(0.0079)	(0.0080)	(0.0079)	(0.0079)
Watercolor	0.0567***	0.0565***	0.0569***	0.0564***
	(0.0058)	(0.0058)	(0.0057)	(0.0057)
Size				
Height	0.0003***	0.0003***	0.0003***	0.0003***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Width	0.0003***	0.0002***	0.0003***	0.0003***

VARIABLES	(1) dummy	(2) dummy	(3) length	(4) number
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Height_2	-0.0000***	-0.0000***	-0.0000***	-0.0000***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Width_2	-0.0000***	-0.0000***	-0.0000***	-0.0000***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Topic				
Abstract	0.0014	0.0013	0.0014	0.0010
	(0.0080)	(0.0081)	(0.0081)	(0.0081)
Animals	0.0098*	0.0096	0.0095	0.0097
	(0.0059)	(0.0059)	(0.0060)	(0.0059)
Landscape	0.0098	0.0096	0.0096	0.0098
	(0.0079)	(0.0080)	(0.0081)	(0.0080)
Seascape	0.0313***	0.0311***	0.0310***	0.0313***
	(0.0057)	(0.0058)	(0.0058)	(0.0057)
Urbanscape	0.0295***	0.0292***	0.0291***	0.0294***
	(0.0051)	(0.0051)	(0.0052)	(0.0051)
Nude	0.0133*	0.0133*	0.0132*	0.0133*
	(0.0068)	(0.0069)	(0.0070)	(0.0069)
People	0.0038	0.0035	0.0035	0.0037
	(0.0056)	(0.0056)	(0.0057)	(0.0056)
Self Portrait	0.0397***	0.0384***	0.0380***	0.0389***
	(0.0124)	(0.0125)	(0.0125)	(0.0125)
Portrait	-0.0318***	-0.0320***	-0.0321***	-0.0320***
	(0.0054)	(0.0055)	(0.0055)	(0.0055)
Religion	0.0072	0.0069	0.0065	0.0071
	(0.0059)	(0.0060)	(0.0060)	(0.0060)
Still Life	0.0092	0.0090	0.0090	0.0092
	(0.0073)	(0.0074)	(0.0075)	(0.0074)
Study	-0.0005	-0.0002	-0.0006	-0.0000
	(0.0058)	(0.0058)	(0.0059)	(0.0058)
Other Topic	0.0214***	0.0209***	0.0208***	0.0212***
	(0.0073)	(0.0074)	(0.0074)	(0.0073)
Transaction Characteristics				
Auction House				
Sotheby's London	0.1139***	0.1087***	0.1076***	0.1105***
	(0.0119)	(0.0112)	(0.0111)	(0.0113)
Sotheby's New York	0.1215***	0.1175***	0.1162***	0.1184***
	(0.0119)	(0.0114)	(0.0114)	(0.0114)
Sotheby's Other Branches	0.1099***	0.1069***	0.1075***	0.1087***
	(0.0202)	(0.0197)	(0.0196)	(0.0197)
Christie's London	0.1486***	0.1384***	0.1366***	0.1408***
	(0.0127)	(0.0119)	(0.0118)	(0.0120)
Christie's New York	0.1735***	0.1665***	0.1655***	0.1677***
	(0.0112)	(0.0107)	(0.0106)	(0.0107)
Christie's Other Branches	0.1214***	0.1182***	0.1178***	0.1201***
	(0.0177)	(0.0168)	(0.0167)	(0.0171)
Bonhams London	-0.0129	-0.0149	-0.0155	-0.0139
	(0.0108)	(0.0106)	(0.0106)	(0.0106)
Bonhams Other Branches	-0.0567***	-0.0579***	-0.0585***	-0.0576***
	(0.0139)	(0.0137)	(0.0137)	(0.0138)

VARIABLES	(1) dummy	(2) dummy	(3) length	(4) number
Phillips London	0.0660***	0.0599***	0.0605***	0.0618***
	(0.0172)	(0.0170)	(0.0169)	(0.0170)
Phillips Other Branches	0.0799***	0.0732***	0.0736***	0.0754***
	(0.0153)	(0.0145)	(0.0143)	(0.0146)
Auction American	0.0861***	0.0858***	0.0859***	0.0856***
	(0.0112)	(0.0111)	(0.0111)	(0.0111)
Auction European	-0.0130	-0.0127	-0.0126	-0.0126
	(0.0185)	(0.0186)	(0.0186)	(0.0186)
Reserve Price				
Reserve Price	-0.0649***	-0.0661***	-0.0668***	-0.0662***
	(0.0036)	(0.0036)	(0.0036)	(0.0035)
Provenance				
Provenance	0.0239***			
	(0.0055)			
Pedigree		0.0173***	0.0044***	0.0211***
		(0.0062)	(0.0014)	(0.0062)
Exhibition		0.0379***	0.0079***	0.0098***
		(0.0041)	(0.0008)	(0.0009)
Literature		0.0250***	0.0056***	0.0092***
		(0.0063)	(0.0011)	(0.0013)
Authentication		0.0102	0.0115***	0.0104
		(0.0133)	(0.0033)	(0.0133)
Artist FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Month FE	YES	YES	YES	YES
Observations	1,707,136	1,707,136	1,707,136	1,707,136
R-squared	0.1747	0.1750	0.1752	0.1750

Table 7 – Hedonic Linear Probability Regression Results with Provenance Details

This table presents the results of hedonic linear probability regression with provenance details. Eq. (2) is estimated using OLS. The dependent variable is the sale results (sold / unsold). The independent variables in this equation are the same with Eq. (1). The descriptive statistics for the independent variables are shown in Table 2. Pedigree, Exhibition, Literature and Authentication are dummy variables if the artworks have any information of pedigree, exhibition, literature, and authentication in Column (1). Column (2) uses number count variables of Prominent Collector, Descent, Sold at Sotheby's and Christie's, Sold at Bonhams and Phillips, Sold at Other Important Auction Houses, Sold at Historic Auction Houses, Prominent Dealer, Prominent Exhibition, Prominent Art Fair, Prominent Museum, Other Museum, Culture City, Catalogue Raisonné, Cover Page, Illustration, and Authoritative Press. Reserve Price is the natural log of low estimates. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors (S.E.) are reported in parentheses and clustered at the auction branch level.

VARIABLES	(1) dummy	(3) number
Reserve Price	-0.0665***	-0.0665***
	(0.0036)	(0.0035)
Pedigree		
Past Ownership		
Prominent Collector	0.0524***	0.0309***
	(0.0113)	(0.0081)
Royal / Noble	0.0656***	0.0657***
	(0.0148)	(0.0151)
Wealthy Families	0.0855***	0.0938***
	(0.0232)	(0.0262)
CEO	-0.0101	-0.0191
	(0.0343)	(0.0312)
Time100	-0.0167	-0.0274
	(0.0372)	(0.0374)
Celebrity	0.0372**	0.0558***
	(0.0170)	(0.0156)
Athlete	0.0948***	0.0952***
	(0.0289)	(0.0293)
Descendance		
Direct from Artist	0.0145***	0.0146***
	(0.0056)	(0.0055)
From Artist Family	-0.0027	-0.0017
	(0.0049)	(0.0047)
From Sitter	-0.0892***	-0.0899***
	(0.0185)	(0.0184)
Descent	0.0288***	0.0215***
	(0.0045)	(0.0035)
Past Sale Channel		
Sold at Sotheby's and Christie's	-0.0060	-0.0072**
	(0.0042)	(0.0030)
Sold at Bonhams and Phillips	-0.0277*	-0.0242*

	(0.0147)	(0.0139)
Sold at Historic Auction Houses	-0.0164**	-0.0161***
	(0.0072)	(0.0058)
Sold at Other Important Auction Houses	-0.0133	-0.0112
	(0.0083)	(0.0080)
Prominent Dealer	0.0377***	0.0247***
	(0.0064)	(0.0080)
Other Collection		
Anonymous Corporate Collection	0.0976***	0.0989***
	(0.0376)	(0.0378)
Anonymous Private Collection	-0.0051	-0.0041
	(0.0084)	(0.0084)
Pedigree Other	0.0274***	0.0268***
	(0.0058)	(0.0057)
Exhibition		
Prominent Exhibition	0.0263***	0.0176***
	(0.0081)	(0.0066)
Prominent Art Fair	0.0015	-0.0006
	(0.0298)	(0.0232)
Prominent Museum	0.0543***	0.0379***
	(0.0083)	(0.0059)
Other Museum	0.0176***	0.0255***
	(0.0042)	(0.0048)
Culture City	0.0192***	0.0053***
	(0.0034)	(0.0011)
Gallery Exhibition	0.0430***	0.0428***
	(0.0077)	(0.0076)
Literature		
Catalogue Raisonné	0.0236**	0.0190**
	(0.0095)	(0.0086)
Cover Page	0.0509***	0.0187*
	(0.0143)	(0.0113)
Illustration	0.0207***	0.0112***
	(0.0079)	(0.0022)
Authoritative Press	0.0130	0.0112
	(0.0183)	(0.0161)
Other Literature	0.0149*	0.0167**
	(0.0081)	(0.0081)
Authentication		
Artist Physical	0.0599***	0.0598***
	(0.0172)	(0.0172)
Artist Family Physical	-0.0166	-0.0167
	(0.0152)	(0.0152)
Association Physical	0.0348**	0.0348**
	(0.0148)	(0.0148)
Expert Physical	-0.0169	-0.0170
	(0.0179)	(0.0179)
Other People Physical	0.0011	0.0009
	(0.0129)	(0.0129)
Artist Non-Physical	0.0348	0.0348

	(0.0224)	(0.0224)
Artist Family Non-Physical	-0.0312*	-0.0310*
	(0.0171)	(0.0171)
Association Non-Physical	-0.0381	-0.0380
	(0.0240)	(0.0240)
Expert Non-Physical	-0.0292	-0.0291
	(0.0211)	(0.0212)
Other People Non-Physical	-0.0206	-0.0204
	(0.0136)	(0.0136)
Artist FE	YES	YES
Attribution	YES	YES
Authenticity	YES	YES
Medium	YES	YES
Size	YES	YES
Topic	YES	YES
Year	YES	YES
Month	YES	YES
Auction house	YES	YES
Observations	1,707,136	1,707,136
R-squared	0.1755	0.1755

Table 8 – Return Regression Results

This table presents the baseline return regression results of repeat sales. Eq. (3) is estimated using OLS. The dependent variable is annualized return of repeat sales. The independent variables in this equation are the same with the first price equation. All the variables ending with "at First Sale" are the provenance variables at the first sale and variables starting with "Changes" are the provenance changes over time. Auction House Upgrade equals one if the artwork is sold at a bigger auction house at the second sale comparing with the auction house at the first sale. Auction House Downgrade equals one if the artwork is sold at a smaller auction house at the second sale. In Column (1) and Column (4), Pedigree, Exhibition, Literature, and Authentication are dummy variables if the artworks have any information of pedigree, exhibition, literature and authentication, respectively. Column (2) and Column (4) use the natural log of text length of pedigree, exhibition, literature, and authentication information. Column (3) and Column (6) use the number count variables of exhibition, literature and the dummy variables of pedigree and authentication. Column (1) – (3) are the full repeat sales sample and Column (4) – (6) use the repeat sales which are sold at the same auction houses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors (S.E.) are reported in parentheses and clustered at the auction branch level.

VARIABLES	(1) dummy	(2) length	(3) number	(4) dummy	(5) length	(6) number
Provenance at First Sale						
Pedigree at First Sale	0.1391	0.0480*	0.1694	0.6753	0.1977	0.7027
	(0.2291)	(0.0270)	(0.1485)	(0.5931)	(0.1282)	(0.6052)
Exhibition at First Sale	0.0553	-0.0069	0.0099	0.1232	-0.0019	0.0466
	(0.0726)	(0.0291)	(0.0394)	(0.2382)	(0.0408)	(0.0414)
Literature at First Sale	0.0919	0.0005	-0.0220	0.1619	0.0062	-0.0404
	(0.0673)	(0.0272)	(0.0566)	(0.1221)	(0.0232)	(0.0414)
Authentication at First Sale	-0.1725	-0.0683	-0.1727	-0.1784*	-0.1153**	-0.1762*
	(0.1189)	(0.0416)	(0.1110)	(0.0943)	(0.0554)	(0.0934)
Provenance Changes						
Changes Pedigree	-0.0551	0.0076	-0.0187	-0.1382	0.0160	-0.1062
	(0.1472)	(0.0232)	(0.1159)	(0.4136)	(0.0691)	(0.4151)
Changes Exhibition	0.1582**	0.0250	0.0232	0.2761*	0.0548**	0.0739*
	(0.0695)	(0.0303)	(0.0424)	(0.1468)	(0.0273)	(0.0391)
Changes Literature	0.1453**	0.0176	-0.0039	0.2706***	0.0413*	-0.0187
	(0.0623)	(0.0247)	(0.0385)	(0.0713)	(0.0223)	(0.0436)
Changes Authentication	0.0068	0.0017	0.0095	0.0227	-0.0054	0.0296
	(0.0595)	(0.0223)	(0.0996)	(0.0612)	(0.0235)	(0.0629)
Auction Houses Changes						
Auction House Upgrade	0.3984***	0.3957**	0.4006**			
	(0.1238)	(0.1625)	(0.1625)			
Auction House Downgrade	-0.1865	-0.1927	-0.1914			
	(0.1531)	(0.1183)	(0.1187)			
Artist FE	YES	YES	YES	YES	YES	YES
Attribution	YES	YES	YES	YES	YES	YES
Authenticity	YES	YES	YES	YES	YES	YES
Medium	YES	YES	YES	YES	YES	YES

Size	YES	YES	YES	YES	YES	YES
Topic	YES	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES	YES
Month	YES	YES	YES	YES	YES	YES
Auction house	YES	YES	YES	YES	YES	YES
Observations	6,647	6,647	6,647	4,236	4,236	4,236
R-squared	0.3369	0.3367	0.3366	0.3940	0.3947	0.3935

Table 9 – Return Regression with Provenance Details

This table presents the baseline return regression results of repeat sales. Eq. (3) is estimated using OLS. The dependent variable is annualized return of repeat sales. The independent variables in this equation are the same with the first price equation. All the variables ending with "at First Sale" are the provenance variables at the first sale and variables starting with "Changes" are the provenance changes over time. Auction House Upgrade equals one if the artwork is sold at a bigger auction house at the second sale comparing with the auction house at the first sale. Auction House Downgrade equals one if the artwork is sold at a smaller auction house at the second sale. Famous Owner at First Sale equal one if the artwork with pedigree information of royal / noble, wealthy families, CEO, Time 100, celebrity, or athlete at first sale. Owner Credibility at First Sale equal one if the artwork is direct from artist, from artist family, from sitter or with descendance information at first sale. Famous Auction House at first sale equal one if the artwork is once sold at Sotheby's, Christie's, Bonhams, Phillips, historically important auction houses, or at other important auction houses. Other Collection at First Sale equal one if the artwork is in anonymous corporate collection or anonymous private collection at first sale. Authentication Physical at First Sale equal one if the authentication information is with physical form and Authentication Nonphysical at First Sale equal one if authentication information is with non-physical form at first sale. Column (1) is the full repeat sales sample and Column (2) uses the repeat sales sold at the same auction houses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors (S.E.) are reported in parentheses and clustered at the auction branch level.

VARIABLES	(1) Full sample	(2) Same Auction houses
Provenance at First Sale		
Prominent Collector at First Sale	0.1586	0.8522
	(0.1714)	(0.6775)
Famous Owner at First Sale	0.3268	-0.3349
	(0.4276)	(0.6137)
Owner Credibility at First Sale	-0.1262	0.5480*
	(0.1108)	(0.2910)
Famous Auction House at First Sale	0.0997	0.4103
	(0.1716)	(0.4031)
Prominent Dealer at First Sale	0.2171	0.8242**
	(0.2114)	(0.3840)
Other Collection at First Sale	0.0057	0.1662
	(0.1070)	(0.3334)
Pedigree Other at First Sale	0.2560	0.6421
	(0.3062)	(0.5509)
Prominent Exhibition at First Sale	-0.0866	0.2826
	(0.2280)	(0.6255)
Prominent Art Fair at First Sale	-0.3467	-1.4739
	(0.5242)	(1.1621)
Museum at First Sale	0.1565*	0.3717*
	(0.0888)	(0.2170)
Culture City at First Sale	-0.0120	-0.1919
	(0.0706)	(0.2071)

Gallery Exhibition at First Sale	0.2348	0.0326
	(0.1757)	(0.2303)
Catalogue Raisonné at First Sale	-0.1245	-0.4358*
	(0.1836)	(0.2516)
Cover Page Illustration at First Sale	0.0736	0.3417
	(0.1087)	(0.3485)
Authoritative Press at First Sale	-0.1370	-0.1642
	(0.1742)	(0.2004)
Other Literature at First Sale	0.1383	0.1892
	(0.0924)	(0.1339)
Authentication Physical at First Sale	-0.1302	-0.1627*
	(0.0960)	(0.0929)
Authentication Nonphysical at First Sale	-0.4125	-0.4253**
	(0.2743)	(0.1964)
Provenance Changes		
Changes Prominent Collector	0.3156**	0.7381*
	(0.1514)	(0.3886)
Changes Famous Owner	1.6297	4.4978
	(1.8188)	(4.0730)
Changes Owner Credibility	-0.0726	-0.0309
	(0.0552)	(0.1337)
Changes Famous Auction house	0.0050	0.1413
	(0.0953)	(0.2549)
Changes Prominent Dealer	0.4603	1.2009***
	(0.4585)	(0.4357)
Changes Other Collection	-0.0210	-0.0157
	(0.0981)	(0.2141)
Changes Pedigree Other	-0.0598	-0.3662
	(0.1845)	(0.4705)
Changes Prominent Exhibition	-0.0911	0.3971
	(0.1867)	(0.5471)
Changes Prominent Art Fair	0.5650	-
	(0.6709)	
Changes Museum	0.2085***	0.6230**
	(0.0722)	(0.2921)
Changes Culture City	0.0271	-0.1277
	(0.0939)	(0.1716)
Changes Gallery Exhibition	0.2866*	0.2700
	(0.1693)	(0.3226)
Changes Catalogue Raisonné	0.0176	0.0011
	(0.1365)	(0.2566)
Changes Cover Page Illustration	0.1436	0.1101
	(0.1213)	(0.3365)
Changes Authoritative Press	-0.1480***	-0.1234
	(0.0540)	(0.1023)
Changes Other Literature	0.1425	0.2916***
	(0.0883)	(0.0956)
Changes Authentication Physical	0.0022	0.0260
	(0.0679)	(0.0529)
Changes Authentication Nonphysical	-0.0530	-0.0645
	(0.1125)	(0.1541)
Auction Houses Changes		
Auction House Upgrade	0.3914***	

	(0.1202)	
Auction House Downgrade	-0.1808	
	(0.1480)	
Artist FE	YES	YES
Attribution	YES	YES
Authenticity	YES	YES
Medium	YES	YES
Size	YES	YES
Topic	YES	YES
Year	YES	YES
Month	YES	YES
Auction house	YES	YES
Observations	6,647	4,236
R-squared	0.3397	0.3997

Table 10 – Hedonic Price Regression for Subsamples by Auction Houses

This table presents the hedonic regression results for subsamples by auction houses. Eq. (1) is estimated using OLS. The dependent variable in Column (1) and Column (2) is the natural log of deflated hammer price in USD; the dependent variable in Column (3) and Column (4) is the sale results (sold / unsold) namely the probability of being sold. Pedigree, Exhibition, Literature and Authentication are the dummy variables if the artworks have any information of pedigree, exhibition, literature, and authentication, respectively. Column (1) and Column (3) use the subsample for big auction houses; Column (2) and Column (4) use the subsample for small auction houses. Lag Average Price is the natural log of lag average price of each auction house. Reserve Price is the natural log of low estimates. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors (S.E.) are reported in parentheses and clustered at the auction branch level.

VARIABLES	(1) PRICE Big auction houses	(2) PRICE Small auction houses	(3) PROB Big auction houses	(4) PROB Small auction houses
Pedigree	0.1743***	0.0973***	0.0161***	0.0240*
	(0.0047)	(0.0065)	(0.0017)	(0.0129)
Exhibition	0.3287***	0.3655***	0.0354***	0.0560***
	(0.0070)	(0.0146)	(0.0024)	(0.0118)
Literature	0.4519***	0.3308***	0.0268***	0.0220
	(0.0075)	(0.0122)	(0.0025)	(0.0147)
Authentication	0.0412***	0.1733***	-0.0231***	0.0254**
	(0.0119)	(0.0066)	(0.0046)	(0.0128)
Lag Average Price	0.2295***	0.2579***		
	(0.0027)	(0.0021)		
Reserve Price			-0.0598***	-0.0711***
			(0.0008)	(0.0050)
Artist FE	YES	YES	YES	YES
Attribution	YES	YES	YES	YES
Authenticity	YES	YES	YES	YES
Medium	YES	YES	YES	YES
Size	YES	YES	YES	YES
Topic	YES	YES	YES	YES
Year	YES	YES	YES	YES
Month	YES	YES	YES	YES
Auction house	YES	YES	YES	YES
Observations	366,604	585,294	601,790	1,083,846
R-squared	0.8103	0.7544	0.1929	0.2006

Table 11 – Hedonic Price Regression for Subsamples by Medium

This table presents the hedonic regression results for subsamples by medium. Eq. (1) is estimated using OLS. The dependent variable in Column (1) - (3) is the natural log of deflated hammer price in USD; the dependent variable in Column (4) - (6) is the sale results (sold / unsold) namely the probability of being sold. Pedigree, Exhibition, Literature and Authentication are the dummy variables if the artworks have any information of pedigree, exhibition, literature, and authentication, respectively. Column (1) and Column (4) use the subsample for oil paintings; Column (2) and Column (5) use the subsample for watercolors; Column (3) and Column (6) use the subsample for drawings. Reserve Price is the natural log of low estimates. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors (S.E.) are reported in parentheses and clustered at the auction branch level.

VARIABLES	(1) PRICE Oil painting	(2) PRICE Watercolor	(3) PRICE Drawing	(4) PROB Oil painting	(5) PROB Watercolor	(6) PROB Drawing
Pedigree	0.1844***	0.1453***	0.2123***	0.0126*	0.0339***	0.0320***
	(0.0169)	(0.0222)	(0.0277)	(0.0067)	(0.0070)	(0.0082)
Exhibition	0.3165***	0.3107***	0.3514***	0.0386***	0.0351***	0.0477***
	(0.0176)	(0.0233)	(0.0384)	(0.0038)	(0.0076)	(0.0115)
Literature	0.3392***	0.4102***	0.4126***	0.0234***	0.0300***	0.0397***
	(0.0307)	(0.0285)	(0.0360)	(0.0067)	(0.0085)	(0.0122)
Authentication	0.1308***	0.1780***	0.0791***	0.0130	0.0120	0.0011
	(0.0234)	(0.0245)	(0.0262)	(0.0140)	(0.0122)	(0.0145)
Reserve Price				-0.0771***	-0.0625***	-0.0649***
				(0.0036)	(0.0054)	(0.0058)
Artist FE	YES	YES	YES	YES	YES	YES
Attribution	YES	YES	YES	YES	YES	YES
Authenticity	YES	YES	YES	YES	YES	YES
Medium	YES	YES	YES	YES	YES	YES
Size	YES	YES	YES	YES	YES	YES
Topic	YES	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES	YES
Month	YES	YES	YES	YES	YES	YES
Auction house	YES	YES	YES	YES	YES	YES
Observations	751,340	223,026	119,048	1,157,799	339,288	187,975
R-squared	0.8156	0.7772	0.7318	0.1950	0.1982	0.2031

Table 12 – Hedonic Price Regression for Subsamples by Schools and Movements

This table presents the hedonic price regression results for subsamples by schools and movements. Eq. (1) is estimated using OLS. The dependent variable is the natural log of hammer price in USD. Pedigree, Exhibition, Literature and Authentication are the dummy variables if the artworks have any information of pedigree, exhibition, literature, and authentication, respectively. Column (1) – (13) are subsamples of art schools and movements: Medieval & Renaissance; Baroque; Rococo; Neoclassicism; Romanticism; Realism; Impressionism & Symbolism; Fauvism & Expressionism; Cubism, Futurism & Constructivism; Dada & Surrealism; Abstract Expressionism; Pop; Minimalism & Contemporary. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors (S.E.) are reported in parentheses and clustered at the auction branch level.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
VARIABLES	Medieval and Renaissance	Baroque	Rococo	Neoclassicism	Romanticism	Realism	Impressionism and Symbolism	Fauvism and Expressionism	Cubism Futurism and Constructivism	Dada and Surrealism	Abstract Expressionism	Pop	Minimalism and Contemporary
Pedigree	0.128***	0.158***	0.138**	0.026	0.245***	0.118***	0.183***	0.073*	0.119**	0.100*	0.155***	0.553***	0.118
	(0.042)	(0.027)	(0.054)	(0.053)	(0.055)	(0.038)	(0.031)	(0.039)	(0.051)	(0.059)	(0.034)	(0.120)	(0.073)
Exhibi	0.368***	0.424***	0.441***	0.345***	0.348***	0.385***	0.449***	0.311***	0.362***	0.363***	0.203***	0.522***	0.348***
-tion	(0.090)	(0.072)	(0.083)	(0.096)	(0.082)	(0.037)	(0.030)	(0.037)	(0.033)	(0.040)	(0.033)	(0.051)	(0.020)
Litera	0.416***	0.373***	0.452***	0.531***	0.345***	0.478***	0.276***	0.368***	0.516***	0.495***	0.516***	0.438***	0.441***
-ture	(0.083)	(0.039)	(0.063)	(0.119)	(0.081)	(0.038)	(0.040)	(0.045)	(0.070)	(0.052)	(0.040)	(0.076)	(0.084)
Authenti	-0.187	0.208***	0.303**	-0.118	0.444***	0.151***	0.139***	0.129***	0.188***	0.052	-0.003	0.153**	0.257***
-cation	(0.132)	(0.046)	(0.126)	(0.195)	(0.087)	(0.050)	(0.041)	(0.038)	(0.052)	(0.044)	(0.045)	(0.076)	(0.065)
Artist FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Attribution	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Authenticity	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Medium	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Size	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Topic	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Month	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Auction house	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	4,634	18,129	4,715	2,802	9,292	14,281	23,553	19,034	14,592	15,467	15,611	9,120	12,739
R-squared	0.682	0.648	0.663	0.652	0.705	0.734	0.779	0.773	0.771	0.767	0.767	0.766	0.775